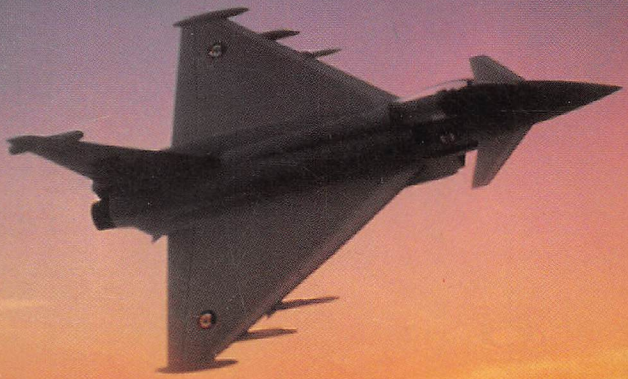
TFX™

TACTICAL FIGHTER EXPERIMENT



INSTRUCTION MANUAL

IBM PC & COMPATIBLES

ocean®

TACTICAL FIGHTER EXPERIMENT

So you want to fly? You want to REALLY fly? Well you made the right choice with TFX ... Take total control of one of three of the finest aircraft money can't buy: the Eurofighter 2000, the Lockheed F-22 Superstar and the Lockheed F-117A Stealth Fighter.

Puncture the clouds and marvel at the view of the world below. Feel the intense thrill of flying low, hard and fast over cities and rolling hills, through a hail of triple-A illuminating the night sky and swarms of hostile fighters.

So you want to fight? In TFX there are entire countries ready to take you on. Fly to South America for crack combat with powerful drug barons. Succeed where so many others have failed in putting a halt to the horror of the Bosnian conflict. Free the world from oppression and earn medals and honors into the bargain.

Even when you manage to make the TFX world a safe place in which to live, you can always construct your own devilish missions to amuse yourself.

But above all: keep the peace.

Introduction

TFX is a computer game, but it is also a flight simulator. While it can be played on a simple level as an action game, it also has a complex flight modeling system which attempts to reproduce many aspects of flight and of the airplanes you will be piloting. If you have played flight simulators before, you will be familiar with much of what this manual describes. While some flight games have little realism, but impressive graphics and plenty of action, some contain much military and aerodynamic detail to reproduce many of the challenges that face a real pilot in a combat situation. In TFX, we have tried to do both. You will know already how advanced the graphics system is, but the flight model has many details never before seen on a home computer simulator.

Some simulations are based on current or past aircraft, and the writers are able to research aspects of cockpit detail, military procedure and flight behavior by reading books and obtaining information from the manufacturers. However, with the three airplanes you will fly in TFX, this was not possible. Of the three, only the F-117A is in service at the time of writing, and even it still has many closely guarded secrets. The Eurofighter 2000 and the F-22 Superstar will enter service with the air forces of western Europe and the USA respectively in the late 1990s, although prototypes and technology demonstrator airplanes have been tested for them.

For this reason, aerodynamic data could not be plucked from books or from technical reports. Test data from the Experimental Aircraft Programme (EAP) and YF-22 prototype were available, but much of the data required was calculated from basic aerodynamic methods. Wing shape, body wetted area and other characteristics were used to make estimates of the airplanes' lift, drag and other aerodynamic performance parameters. Luckily, these calculations corroborated quite well with the published data. Some published data turned out to be inaccurate, when judgements had to be made between conflicting sources of information. On some factors, no information was available. Then, I had to make educated guesses based on similar airplanes and common sense requirements.

Essentially, TFX is a speculative simulation of the cutting edge of aerial warfare. It is, in the end, entertainment, but I hope, for the research and effort put into the model, it is entertainment of a positive and rewarding nature.

Roderick Victor Kennedy, Aeronautical Engineer & TFX Consultant, September 1993

limited warranty

TFX

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This software product has been carefully developed and manufactured to the highest quality standards. Please read carefully the instructions for loading. This game has been checked and tested for viruses. Please do not use any form of disk utility with any Ocean product as it may corrupt the data and render it unusable.

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caution!

Diskettes are magnetic media, just like cassette tapes and video tapes. Do not expose diskettes to x-rays or intense magnetic fields as the data they hold will be erased. Do not attempt to 'back up' this data as it may be destroyed in the process.

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Section one

getting started

SYSTEM REQUIREMENTS

TFX is highly compressed on the program disks and remains highly compressed once installed on the hard disk, taking up 12 MB of space instead of 40 MB. All data is decompressed in real time. Normal compression programs will not be able to compress it further.

TFX requires a 386 or 486 IBM PC compatible with either 4 MB of extended memory or 4 MB of extra disk space if the RAM is not present. RAM is used wherever possible, but it is not necessary. Virtual Memory. TFX will run from a Superstore drive or any form of compression software, e.i., Stacker and DoubleSpace. However, it must be noted that compression software may cause installation to fail because the program assumes there is sufficient free hard disk space.

The more disk space and machine RAM available, the faster TFX will run.

Section two

TFX configuration

Until you become comfortable with TFX's level of realism, we recommend you select 'EASY' settings (or equivalents), to get into the swing of things. As your confidence grows you can make life more difficult for yourself and learn how to really fly by bumping up the settings. To return to TFX Configuration menu, press the "accent" key. key

MAIN MENU

FLIGHT CONTROLS Choose from 'JOYSTICK', 'MOUSE' or 'KEYBOARD' to control the basic flight of the aircraft. Note that the mouse is always used for the selection of options.

WORLD DETAIL There are three levels: 'LOW', 'MEDIUM' or 'HIGH'. The lower the level of detail, the faster TFX runs.

FLIGHT MODEL You decide the level of realism of the flight model and consequently the effect of forces on the aircraft and its handling. Choose from 'ARCADE', 'SIMPLE', 'REALISTIC' and 'MILITARY SPEC'. The choice depends on your confidence and ability.

ARCADE Flight models don't come much simpler than this ... You can defy the laws of physics and have a ball. You can fly at ridiculous speeds but cannot stall or crash and you won't be affected by extreme turns.

SIMPLE A little more complicated than the Arcade flight model.

REALISTIC Very, but the aircraft are still simple enough to fly as the onboard computers take care of most of the hard work, leaving you to enjoy the flight - and combat, of course.

MILITARY SPEC The creme de la creme of flight models. There has never - repeat, never - been a flight model as authentic as this for the home computer. Note that when using the Military Specification flight model, additions are made to the HUD, the MFDs, and more besides (further details are found in the relevant sections).

SOUND FX The noises made during play may be turned 'ON' or 'OFF'. If possible, leave the sound effects on - they can help enormously (especially the speech).

MUSIC Turn 'ON' or 'OFF' all the atmospheric music.

QUIT TO DOS The same effect may be achieved during play as follows:

- Press and hold the left-hand shift key then press the Q key to pull up an options screen where you can quit to DOS or quit to the enroll screen. If you quit to the enroll screen, it will not affect your log (as if you have never played the mission) .
- Press and hold the left-hand shift key then press the Q key again to return to DOS.

REALISM MENU More advanced options. See below for further details.

REALISM MENU

G EFFECTS The force of gravity can have unpleasant side-effects on pilots in flight (see G-FORCE on page 36). Choose from 'NONE', 'REDUCED' or 'REALISTIC' to determine the extent of redout or blackout when pulling high g's.

LOSS OF CONTROL Choose from 'NONE', 'PARTIAL' or 'ALL' to determine the extent of control loss in extreme circumstances in flight.

CRASHING Select 'ON' to ensure that ground crashes destroy your aircraft.

GEAR DAMAGE Select 'ON' to ensure that rough landings and high airspeeds damage your landing gear.

WIND Select 'ON' to activate the effects of wind when using the Military Specification flight model. See WEATHER CONDITIONS overleaf for further details.

TEMPERATURE Affects the aerodynamic characteristics of the air. When this option is 'ON', the temperature will vary with geographic area, weather conditions and time of day. See WEATHER CONDITIONS overleaf for further details.

PRECIPITATION Mainly affects runway quality, in that a wet runway can lengthen takeoff distance. Select 'ON' to ensure that rain or snow will fall and cause problems.

WEATHER CONDITIONS

Note that these only affect the aircraft when using the Military Specification flight model.

Wind conditions vary with geographic area, weather and altitude. Obviously, wind will be very high in a storm, but higher winds will be experienced in the South Atlantic than in Italy. Additionally, TFX models the high altitude gulf stream patterns which are created by the Earth's rotation. In each world area, these are treated as 100-140 knot winds which occur in the stratosphere (above about 30,000 ft) and are roughly constant in direction and magnitude.

Bear in mind that temperatures are higher in hotter countries. That said, African nights are very cold, whereas in Colombia, cloud traps the heat, and there is less variation in temperature.

Section three

to begin...

An introductory sequence sets the scene.

• Press the Esc key to skip the introductory sequence.

Once the introductory sequence and credits have been shown you will be presented with two options: 'CREATE NEW PILOT' (highlighted in red) and 'LOAD PREVIOUS GAME'. Use the arrow (cursor) keys to move the red highlight between the options.

• Press the Enter key to select the highlighted option.

• Press the Accent key to return to configuration menu.

CREATE NEW PILOT

When you are prompted to enter your first name, your surname and your callsign, use the keyboard to type any combination of letters and numbers up to a maximum of 20 characters. The default name and callsign are DIRK INFERNO and LOOSE CANNON.

• Press the Enter key to register your name and callsign.

Your name and callsign are used to personalize your pilot's log which is saved to one of 10 'slots' on the hard disk. The pilot's log records your performance in play (note: Arcade and Simulator excepted), retaining such statistics as the number of enemy kills you make, the number of missions you complete, your score, rank and flight time. Use the arrow (cursor) keys to highlight one of the slots and view further details at the bottom of the screen.

• Press the Enter key to select the highlighted slot.

Note that if you select a dead pilot's log or a blank slot, you will have to enter fresh details.

MAIN OPTIONS SCREEN

Having picked a pilot's log you are presented with the Main Options Screen. Further options - to tailor the TFX environment to your taste - are available during play (see section 2: TFX CONFIGURATION on page 2). All options are now selected with mouse-controlled pointers. Simply move the mouse-pointer's tip to touch the desired option and press the left-hand mouse button to select it.

The Main Options Screen

There are six key ways to play TFX - from simple arcade-style action to hard-core real-world combat simulations. You can even build your own missions with the UN Commander option. Note that when you become involved with the Training, Flashpoints or Tour Of Duty options, you are susceptible to all rules and regulations and run the risk of Court Martial, capture and more ...

Almost every man-made object in the TFX environment is worth points. You score points for every authorized enemy target you destroy. However, as a UN peace envoy, you are not expected to fly around blowing up all and sundry. Unless you wish to incur the wrath of the media and the UN Command, do not fire unless fired upon - or you have been given specific permission to take out hostile targets. Your score is reduced significantly should you decide to attack anything other than a 'legitimate' target. Hospitals and churches, for example, are best left alone as the penalties for their destruction are severe, particularly in Training, Flashpoints and Tour Of Duty situations.

Points are also awarded for classy flying - especially in dangerous weather conditions. Basically, the greater your display of skill, the more points you score.

As missions are completed, your rank increases and special awards may be given. In TFX you start as a Second Lieutenant. With skill (and a little luck) you should (ahem) fly through the ranks of First Lieutenant, Captain, Major, Lieutenant Colonel and Colonel to become a General.

ENROLL TO UNAF

Select this to create a new pilot's log or load a previously created one.

ARCADE

To get a feel for TFX, there's no better place to start than here.

There are no takeoffs and landings to worry about, and it doesn't matter if you somehow manage to live or die or lose your aircraft (it's impossible to crash it, but you may be blown away) - you can always start again and attempt to improve your score.

The Arcade option comprises five levels of increasing difficulty. Each level represents a unique environment with different terrain, times of day, weather conditions, and levels of enemy competence (from a handful of amateur MiG-21 pilots to squadrons of veteran MiG-29 pilots). You also get to knock out ground targets including factories, SAM radar sites and air bases.

Note that your aircraft is automatically armed. The weapon selection depends on your choice of aircraft (the F-117A cannot be flown here). Chaff and decoy flares are in restricted supply, but you do get unlimited ammunition and fuel to play with.

TRAINING

There's only one way to become involved with the deep and meaningful Flashpoints and Tour Of Duty campaigns, and that's to undertake and complete a carefully considered selection of training missions. No, that's not entirely true: there is another way to prove yourself worthy, but that's for you to discover ...

The 10 Training missions are designed to help familiarize you with all aspects of TFX. You will fly all three aircraft through a broad spectrum of combat situations. The choice of weaponry is yours. Where you fly from - in the air or on a land- or aircraft carrier-based runway - depends on the mission in question.

SIMULATOR

Fly the way you want to with no rules or regulations to hold you back.

With the Simulator there are no points to win or lose, no awards to earn, and no threats of court martial ... This is unadulterated flight and fight simulation at its best.

You choose the location, the weather conditions and the time of day to determine the aircraft you will control and from where you will fly it: in the air or a land- or carrier-based runway. You also get to arm the aircraft with whatever weaponry it can take (see ARMING YOUR AIRCRAFT on page 35), but choose wisely: consider what would be appropriate for your previously selected specifications.

TOUR OF DUTY

Enroll to one of three squadrons - the F-22 Superstars, the F-117 Darkstars or the EF-2000 Blue Angels - and become involved in their actions around the world. But this is more than a glorified world tour ...

The theater of operations will become apparent when the time is right. A full brief of the situation at hand will be given along with a map of the area in which the mission takes place.

- *Press the Space Bar to step through a numbered breakdown of the mission.*
- *Press the right-hand mouse button to skip the mission briefing.*

Now arm your aircraft. Where you fly from - in the air or on a land- or aircraft carrier-based runway - depends on the mission in question.

FLASH POINTS

Five true-to-life storylines with a mission structure - an interactive soap opera, if you will. The way you play will change the course of history, for better or worse. Pick a scenario, any scenario. Now pay close attention to the news reports, press conferences, UN Assembly crisis meetings and orders from the top brass as the story's background unfolds and the scene is set before your very eyes ...

- *Press the left-hand mouse button to skip any stage of the background information.*
- *Press the spacebar or the Esc key to move on to the next mission.*

An aircraft and weaponry suitable to the mission at hand will be chosen for you. All you have to do is complete the missions ...

UN COMMANDER

Build your own missions with ease from the comfort of UN Central Command. It wouldn't be wise to fly an F-117A Stealth Bomber over a hostile terrain, in the middle of the day, for all to see, and here's where you can find out why ...

Choose anywhere in the TFX world and use satellite imagery to scan the area. Select your targets, determine the time of day, the weather conditions, the quantity and quality of threats and more besides.

Pick an aircraft, arm it and then attempt to score as many points as possible and see if you can beat yourself at your own game. You can even save the missions to hard disk and then copy them to floppy disk to swap with your pals.

For further details, see BUILDING A MISSION on page 42.

Section four

the cockpit

Although some functions and instruments vary slightly between the three aircraft flown in TFX, the same generic cockpit is used throughout. In general, the cockpit utilizes the latest in Multi-Function Display technology for clear and concise information flow.

When designing a multi-billion dollar super jet, a great deal of time and effort is spent to house the pilot in a comfortable, electronic environment not congested with hundreds of individual unimportant instruments such as cigar lighters. The instruments show exactly what the pilot needs to know at any one given time. For example, designers made it possible for the Eurofighter 2000 pilot to concentrate on hostile threats and potential danger and not have to worry about flying the aircraft.

Within the cockpit the displays are arranged in appropriate functional groups including engines and other related systems (on the far left-hand side), electronic counter measures and avoidance systems (on the far right-hand side), and vital warnings for incoming missiles, onboard faults and so on (the top section).

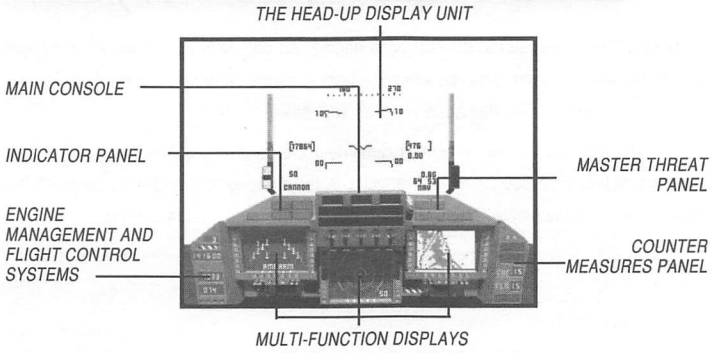
The cockpit has a simple color coding system for the information displayed:

GREEN The system is active and functional

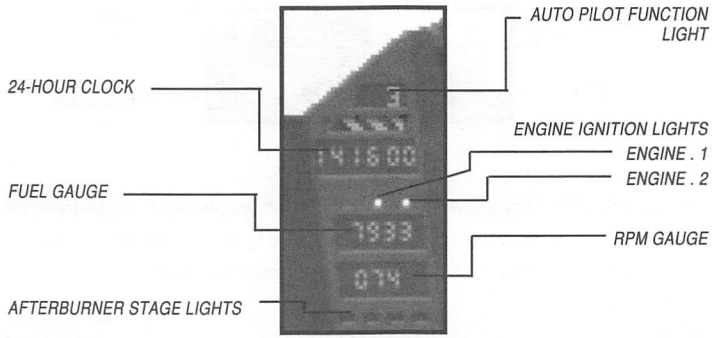
YELLOW Caution! The system has sustained slight damage

RED The system is damaged beyond repair

THAT INSTRUMENTATION IN DETAIL...



ENGINE MANAGEMENT AND FLIGHT CONTROL SYSTEMS



AUTO PILOT FUNCTION LIGHT Shows that the auto pilot is active. The number displayed next to the light shows the mode. For further details, see THE AUTO PILOT.

1 WAYPOINT

2 HEADING

3 TRACKING

4 AUTO THROTTLE

24-HOUR CLOCK Shows the time expired or the local time of day.

the cockpit (cont.)

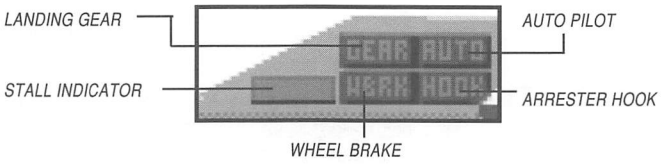
ENGINE IGNITION LIGHTS One for each engine. An engine is shut down when its light is red. Ignition has been achieved when the light is green. Note that if either light flashes or turns red, the engine is damaged and may shut down.

FUEL GAUGE Shows the amount of remaining fuel in pounds. A yellow caution light means that less than 500 lbs of fuel remains. A red warning light and a message on the HUD means that the fuel level has fallen to a dangerous level - below 200 lbs.

RPM GAUGE Shows the amount of engine thrust being applied. The RPM should not drop below 60 per cent while in flight. When afterburners have been activated, the RPM will be at 100 per cent.

AFTERBURNER STAGE LIGHTS One for each increase in power (beware that afterburners consume vast amounts of fuel). Note that the F-117 does not have any afterburners.

INDICATOR PANEL



STALL INDICATOR The light flashes when the aircraft is approaching a stall and stays on when the aircraft has stalled (it may be accompanied by an audio warning). To recover from a stall, increase your throttle and push the aircraft's nose down - or hit the Panic Recovery Button!

CONTROL PANEL A status panel for four key systems: landing gear, auto pilot, wheel brake and arrester hook. The status of the respective systems are indicated by the following colors:

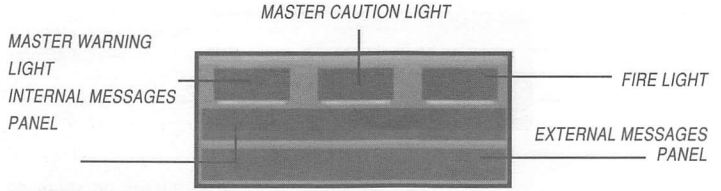
GREY The system is inactive but functional.

GREEN The system is active and functional.

YELLOW Caution! The system has sustained slight damage.

RED The system is damaged beyond repair.

MAIN CONSOLE



MASTER WARNING LIGHT It only illuminates when an onboard function is damaged. Check the MFD Warning Panel to discover the specific problem.

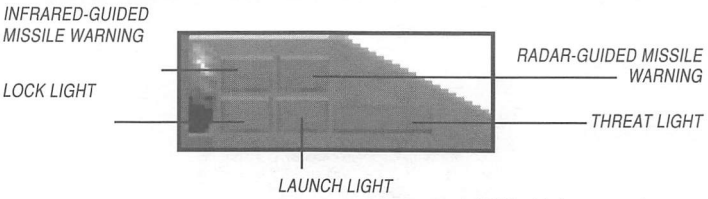
MASTER CAUTION LIGHT It only lights up when there are problems or faults which may be repaired while in flight. Check the MFD Warning Panel to discover the specific problem.

FIRE LIGHT It lights up to show that one or both of the engines are on fire. Your best bet is to eject ASAP.

INTERNAL MESSAGES PANEL Status information from your onboard computer is displayed here.

EXTERNAL MESSAGES PANEL Communication from AWACS, Control Towers and so on is displayed here.

MASTER THREAT PANEL



LOCK Lights up when an enemy radar has fixed a lock on your aircraft. Use ECM and chaff to attempt to break the lock.

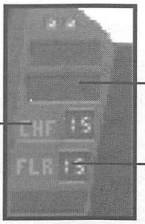
LAUNCH An instant alert to danger when an enemy missile is launched from within a range of approximately 30 miles (air-to-air) or 50 miles (air-to-ground).

INFRARED-GUIDED MISSILE WARNING Lights up when an infrared-guided missile is heading for your aircraft.

RADAR-GUIDED MISSILE WARNING Lights up when a radar-guided missile is heading for your aircraft.

THREAT LIGHT Activates when any unidentified aircraft appears on your radar or within a certain range. Note that the radar does not need to be in air-to-air mode for the Threat Light to activate.

COUNTER MEASURES PANEL



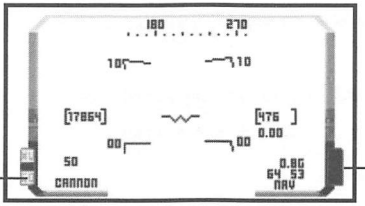
ECM AND STEALTH INDICATOR Lights up to show that your aircraft's ECM or stealth systems are active. Note that only the F-22 and Eurofighter 2000 have the capability to become radar invisible.

CHAFF INDICATOR All three aircraft have a maximum of 15 Chaff canisters.

DECOY FLARE INDICATOR All three aircraft have a maximum of 15 Decoy Flare canisters.

BASIC HUD INFORMATION

For details of the HUD itself, see page 18.



AoA INDEXER A fixed display showing the aircraft's angle of attack on approach to the runway for landing. The following lights provide specific information regarding your AoA:

TOP Your AoA is too high because your airspeed is too low.

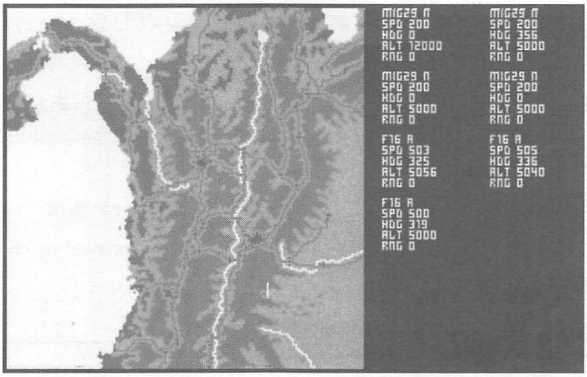
MIDDLE Your AoA is good for landing.

BOTTOM Your AoA is too low because your airspeed is too high.

UNDERCARRIAGE DISPLAY The bottom light comes on when your aircraft's undercarriage is on the ground. The top light (NW) informs you that steering is now performed by the nose wheel of the aircraft so that the aircraft can taxi and manoeuvre on the runway.

THE MAP

The overview of your theater of operations is not shown on the cockpit but is always accessible. Information on any hostile aircraft your radar is currently tracking is shown on the right-hand side of the map. Your systems can track up to 10 hostile aircraft at once.



The Map

• *Press the M key to call up the Map.*

RED Enemy aircraft

RED WHITE FLASHING Authorized enemy ground target.

ORANGE Mobile surface target, e.g., a ship or tank

GREEN Friendly aircraft

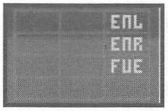
BLUE Friendly surface craft, e.g., a ship or a tank

BLUE WHITE FLASHING Runway selected for landing.

MULTI-FUNCTION DISPLAYS

Press 1 key to cycle through MFD1

Each aircraft has three MFDs which incorporate the following displays:



MASTER WARNING PANEL Shows which of the main systems is currently operational and their current status.

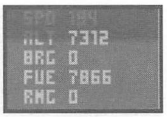
GREEN The system is active and functional.

YELLOW Caution! The system has sustained slight damage.

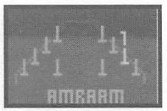
RED The system is damaged beyond repair.

MASTER WARNING PANEL ABBREVIATIONS It certainly helps to know what the following abbreviations refer to when they appear.

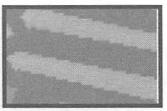
- **ENL** Left Engine
- **ENR** Right Engine
- **WEP** Weapons
- **FUE** Fuel
- **ABK** Air Brakes
- **WBK** Wheel Brakes
- **UC** Undercarriage
- **COM** Communications
- **FLP** Flap
- **HUD** Head-Up Display
- **RAD** Radar
- **OIL** Oil Pressure



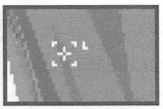
SYSTEMS DISPLAY Provides current flight details including RPM, speed, altitude, fuel and possible range with the present fuel load.



WEAPONS DISPLAY A diagrammatic overview of the aircraft's pylons and any weapons on them. Also shown is the type of each weapon, and which weapons are armed.



FORWARD LOOKING INFRARED VIEW The FLIR shows a forward view through your laser target designator when it is not yet locked on to any ground-based object. When you lock on an object the display will automatically change to the DLIR.



DOWNWARD LOOKING INFRARED VIEW The DLIR shows the target locked on to by the laser designator. For further details see USING THE LASER TARGET DESIGNATOR on page 38.

GROUND TARGET DATA BANK Shows your target and its distance from your present point - in an air-to-ground mission.

• Press the N key to switch between target views.

Press 2 key to cycle through MFD2

The TFX aircraft are fitted with the latest Westinghouse multi-role radar with variable scan and track modes including air-to-air and air-to-ground, and a map display. The symbology remains the same in all modes.

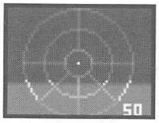
Activating the radars will break Stealth mode if it is operational, so don't activate your radars if you wish to remain invisible to enemy radar. The only 'safe' radar is the moving map display which uses a passive radar system which does not scan and emit any signal - it only receives information.

AIR-TO-AIR RADAR SYMBOLOGY

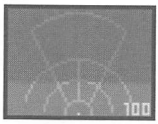
RED DOT Hostile aircraft
RED SQUARE Hostile aircraft you are currently tracking
GREEN DOT Friendly aircraft
RED FLASHING DIAMOND An airborne missile
YELLOW FLASHING DIAMOND Friendly missile

AIR-TO-GROUND RADAR SYMBOLOGY

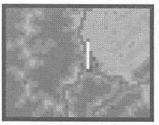
RED DOT Hostile mobile surface target, e.g., a ship or tank
RED FLASHING DIAMOND Airborne missile
RED FLASHING DOT SAM radar
BLUE DOT Friendly surface craft, e.g., a ship or tank



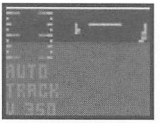
HORIZONTAL SITUATION RADAR Provides a 360 degree horizontal scan up to a radius of 50 miles around your aircraft. It is common for close formations of aircraft to appear as a single 'trace' or dot, which is where the variable range search comes into effect ... Switch between a radius of 50 miles, 30 miles 10 miles and 2 miles (the range is shown in the bottom right-hand corner of the display). Note that the radar only shows relevant data when the aircraft is in either air-to-air or air-to-ground mode.



BEYOND VISUAL RANGE RADAR BVR radar is used for long range scans and to target long range air-to-air missiles. A narrow beam can scan up to 120 miles (180 miles if the area is clutter free - for example, the ocean). The BVR radar can determine whether an aircraft is hostile but the immense distance means that precise tracking data will not be given.



MOVING MAP DISPLAY (MMD) A digitally-generated map which moves relative to your aircraft in the center of the display. A white line indicates your aircraft's direction, and its heading is given. The MMD also shows authorized ground targets (flashing red and white) and airborne radar traces of any aircraft relevant to your location. A full map of your theater of operation is always available.



CONTROL MFD. Displays information regarding the in-flight control of your aircraft. In an F-22 or Eurofighter, the mission adaptive wing indicator in the top right-hand corner shows a schematic representation of the wing cross-section. A short line on the left-hand side of the Control MFD shows the angle of deflection of the leading edge flaps or slats (although in fact slats move in a more complex way). A longer line on the right-hand side shows deflection of the trailing edge flaps. The greater the downward deflection of the flaps, the more lift they produce. Normally the flaps are automatically adjusted in flight according to the aircraft's needs, but if the flaps become damaged, they may lock in position.

In an F-22, thrust vectoring angles are indicated in the top left-hand corner of the Control MFD. The maximum deflection is 20 degrees up or down.

Control mode information is shown below these displays. The sensitivity of the aerodynamic controls is automatically adjusted to suit your situation. The modes are as follows:

CRUISE Medium sensitivity - the normal mode

COMBAT Highly sensitive - for air-to-air combat

LANDING Insensitive - for a steady landing

AUTO Auto pilot

Note that when the auto pilot is activated, further information is displayed. See THE AUTO PILOT on page 25 for more details.

THE HEAD-UP DISPLAY UNIT (INCLUDING HELMET MOUNTED HUD)

The Head-Up Display provides important data for the pilot during all aspects of flight. It is the most important instrument you will use in TFX. The helmet-mounted HUD comes into effect when the cockpit is not shown, for example, when using the full forward view.

The HUD has three main modes as follows:

** NAVIGATION MODE*

** AIR-TO-AIR MODE*

** AIR-TO-GROUND MODE*

It also has two sub-modes: INSTRUMENT LANDING SYSTEM and REFUEL.

To adjust the intensity of the HUD color to a comfortable setting, use the "y" key to decrease and the "u" key to increase.

Note that when using the Military Specification flight model, the HUD displays extra information: an Angle of Attack indexer, a Vertical Speed Indicator and Mach number (see page 24).

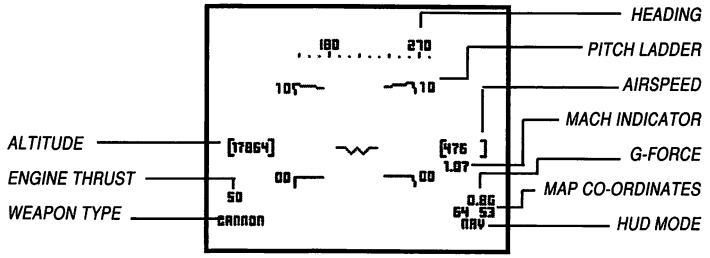
NAVIGATION HUD MODE

A non-combat flight mode which provides both air-to-air or air-to-ground radar capability and a cruise control flight model. Note that the cannon becomes the only available weapon.

•Press the right hand Control key to select the navigation mode HUD.

•Press Enter to return to Radar.

Certain details are common to all HUD modes as follows:



The Navigation HUD

AIRSPEED In knots. Mach speed is also shown with the Military Specification flight model.

ALTITUDE In feet, from sea level.

ENGINE THRUST Shows the percentage of thrust applied by your engines.

G-FORCE The current gravity force upon you and your aircraft. The g-force indicator will read '1G' when your aircraft is flying level or is stationary. For further details see G-FORCE on page 28.

HEADING In units of 10 degrees. North is at 0 degrees, East is at 90 degrees, South is at 180 degrees and West is at 270 degrees.

MAP CO-ORDINATES Your current location in the world on a grid reference of 0 to 200 along X and Y axes. The center of the theater of operations is 100, 100. The farthest Southwest point is 0, 0, and the farthest Northeast point is 200, 200.

WEAPON TYPE The available weapon depends on the HUD mode.

PITCH LADDER A series of lines which move, relative to your aircraft's motion, through the center of the HUD. The Pitch Ladder bars show your aircraft's angle of climb and dive, and its roll angle. The center Ladder Bar at 0 degrees is horizontal - to reflect the aircraft's status. The steeper the aircraft's angle of climb or dive, the more acutely triangular the shape of the Ladder Bars.

HUD MODE Shows the HUD mode in use. The HUD symbology changes and relevant weapons become available. For further details, see the sections that follow.

NAV Navigation mode

AA Air-to-Air mode

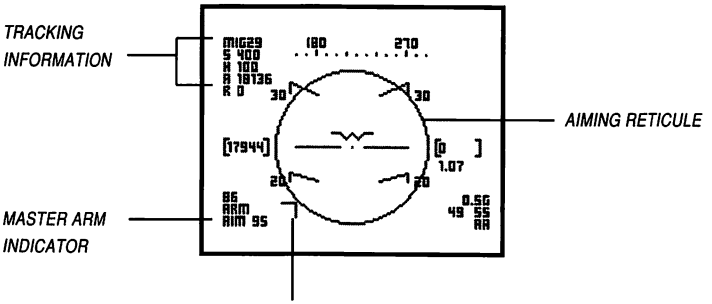
AG Air-to-Ground mode

ILS Instrument Landing System mode

AIR-TO-AIR HUD MODE

When this mode is chosen, the air-to-air radar is activated, the flight model is adjusted to a more appropriate air-to-air combat profile, and air-to-air missiles can be launched. The HUD symbology becomes combat-specific.

- *Press the Enter key to select the air-to-air HUD mode.*
- *Press the Enter key again to cycle through any air-to-air missiles on board and activate the relevant air-to-air systems.*



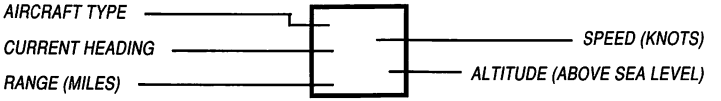
The Air-To-Air HUD

MASTER ARM INDICATOR Informs you that the currently selected weapon is armed and ready to fire.

AIMING RETICULE This 'kill circle' appears on the HUD when an air-to-air missile is selected. The size of the Aiming Reticule depends on the chosen missile: a small circle is used for long-range stand-off weapons such as the AAAM, and a large circle is for short-range missiles. Your target must be inside this circle if the missile is to hit it.

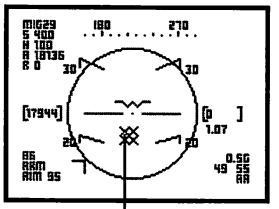
ASPECT ANGLE CARET Shows the target aircraft's heading relative to you. If the caret is at the bottom of the Aiming Reticule, the target is flying away from you. If the caret is at the top, the target is flying toward you.

TRACKING INFORMATION On any aircraft being tracked by your radar as follows:



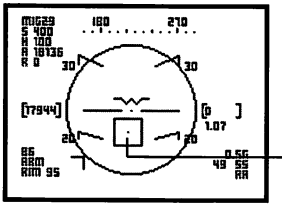
Air-To-Air HUD Tracking Information

• *Press the C key to toggle tracking between any aircraft within range.*



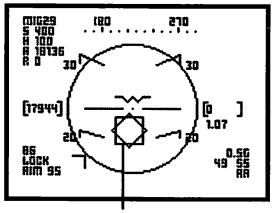
DIAMOND X

DIAMOND X When you see this diamond with an 'X' at its center, you will know that a target is outside the HUD view. Fly in the direction of the Diamond X until the target enters the HUD view. The Diamond X will change to a Target Designator Box.



TARGET DESIGNATOR BOX

TARGET DESIGNATOR BOX Appears around the target when it's inside the Aiming Reticule - even if the target is beyond visual range.



MISSILE SEEKER HEAD

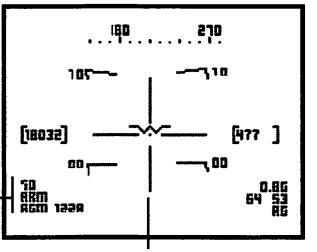
MISSILE SEEKER HEAD When a target has been picked up by the designator box and is in range, the Missile Seeker Head diamond appears inside the HUD's Aiming Reticule. The diamond will come to rest and flash when the Missile Seeker Head locks on to the enemy target. The currently selected missile is now locked on to the target and ready to launch.

THE BIG X Flashes across the entire HUD when the target is too close to be hit with your currently selected weapon - in which case switch to a short-range weapon such as the cannon.

AIR-TO-GROUND HUD MODE

When this mode is chosen, air-to-ground targeting radars are activated, the flight model will change to air-to-ground attack profile and air-to-ground weapons can be selected. If your aircraft is carrying GBU bombs, the Laser Target Designator will become available. When a weapon is in range, then "IN RNG" appears on the bottom left of the HUD. For some air-to-ground missiles, the actual distance to the target being shown may be presented until the "IN RNG" appears.

• *Press the backspace key to select the air-to-ground HUD mode.*



Air-To-Ground HUD

MASTER ARM INDICATOR Informs you that the currently selected weapon is armed and ready to fire.

THE AIMING CROSS The most prominent feature of air-to-ground mode is this crosshair which is used to target air-to-ground weapons.

LAUNCHING NON-GBU WEAPONS

LAUNCHING MAVERICK MISSILES To target a non-GBU or non-guided weapon, line up your aircraft with the target until it is shown in the HUD crosshair.

• Press the spacebar to lock on to the target.

When you have locked on to the target (also known as 'pickling the target'), a target designator box will be shown. (The target designator box will appear over any ground target with a lock on it, whether it was made by 'pickling' or by the Laser Target Designator.)

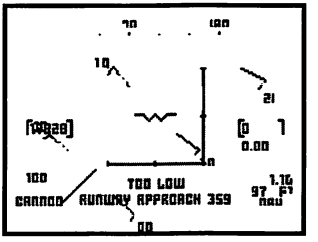
• Press the spacebar again to launch the missile.

DROPPING A MK82 FREEFALL BOMB When you select this weapon, a Continuous Computerized Impact Point (CCIP) line emanates from the center of the crosshair on the HUD. The CCIP line shows the path the weapon will take if it is launched at that moment. A small circle at the end of the line shows the projected impact point, which means that the aircraft is at a suitable angle to launch the weapon. Approach the target at a steep angle (30-40 degree dive) and as soon as that small aiming circle on the end on the line crosses the target, release the bomb. Note: this is best done at an altitude of 2,000 ft or more.

CANNON When the air-to-ground cannon is selected, a trajectory line appears on the HUD to project the impact point of the cannon fire.

INSTRUMENT LANDING SYSTEM HUD MODE

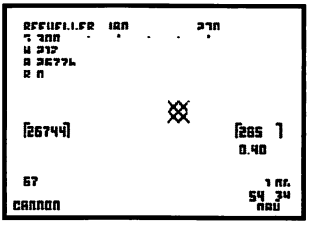
A variation of the navigation mode HUD comes into effect when the Instrument Landing System is activated.



Take note of the information displayed at the bottom of the HUD and use it in conjunction with the HUD guidelines and the AoA Indexer to make a perfect landing.

REFUEL HUD MODE

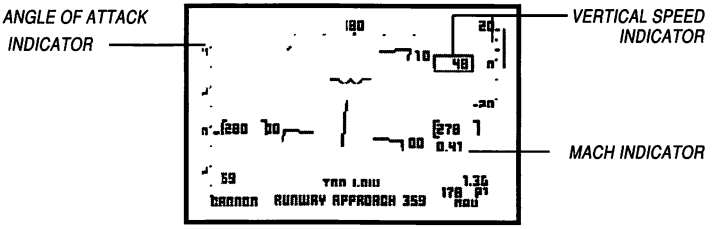
A variation of the air-to-air HUD comes into effect when you are set to refuel (see REFUELLING on page 33).



Instead of an enemy target, the HUD tracks the refuel aircraft. Note that all weapons systems are shut down for refuelling.

MILITARY SPECIFICATION FLIGHT MODEL HUD

The HUD has a few extra features when using the Military Specification flight model.



Military Specification HUD

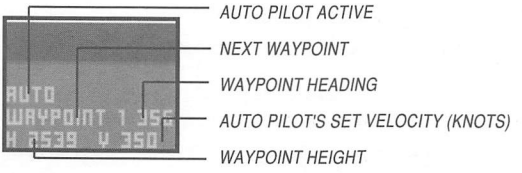
ANGLE OF ATTACK INDICATOR Your aircraft's - in 10 degrees increments.

VERTICAL SPEED INDICATOR Shows the vertical speed of the aircraft in units of feet per second. The VSI is mainly used to perform good landings (a healthy VSI landing speed is up to 10 feet per second).

THE AUTO PILOT

TFX has a 'proper' auto pilot system which controls the aircraft by adjusting joystick and throttle inputs. There are four main modes, as well as a special 'panic button' mode. When auto pilot is activated, the Control MFD shows the auto pilot mode and any appropriate data.

The following details (shown on the Control MFD) are inputs to the auto pilot which adjusts the aircraft controls in an attempt to match your requirements.



MODE 1: **WAYPOINT** Directs your aircraft at the chosen speed to the next waypoint. Use the up and down arrow (cursor keys) to adjust the waypoint altitude.

MODE 2: **HEADING** Maintains the required heading, altitude and speed - adjusted with the arrow (cursor) keys.

MODE 3: **TRACKING** Directs your aircraft toward the aircraft you are tracking on radar. The default speed is the aircraft's own, but adjustments can be made.

MODE 4: **AUTO THROTTLE** Leaves the joystick (or mouse or key) control in the hands of the pilot, but uses throttle to maintain the speed shown in the Control MFD. Your aircraft's speed will not remain constant in all situations, for example, no great speed can be sustained in an 80 degree climb.

RECOVERY MODE A special feature of the Eurofighter 2000 and many Russian-built fighters. In TFX it is available for all three aircraft. The aircraft is returned to straight and level flight. It is not a guaranteed crash evasion technique, so it should be used early, if you become disoriented, or are in a steep dive.

Section five

how to fly

Here's Rod Kennedy to hold the hands of anyone using the Military Specification flight model for the first time.

TAKEOFF

At the start of the flight you will find yourself at one end of a very long runway, with your engines off. Before switching them on, check the weather conditions (if you have weather activated).

- *Press and hold an Alt key then press the W key to check the weather conditions. The information is displayed in the Internal Communications area.*

The following points must be considered:

- *If the runway is wet or icy, you require a longer takeoff distance.*
- *If you have a full tank of fuel and a lot of stores, you require a longer takeoff distance and a higher takeoff speed.*
- *If the wind is coming from your tail, you require a higher takeoff ground speed.*
- *If the wind is coming from in front, your takeoff ground speed will be lower. (It is always better to take off into headwind.)*
- *If the wind is coming from either side, be careful. If you are in an F-117A, you require a long takeoff distance, but the Eurofighter and F-22 are short-takeoff aircraft.*

Now check your controls. Make sure your wheel brakes and air brakes (if you have them) are off. Now, activate your engines and put throttle to 100 per cent. If you have afterburners and need to shorten your takeoff run, turn them on and increase the stages as necessary. You should find you are beginning to move down the runway at increasing speed. When you reach the stated takeoff speed for the aircraft you are flying, start to pull back on the joystick (or the mouse, or press the 'down arrow' key). Your angle of attack indicator should start to rise. Keep clear of the stall angle (about 25-30 degrees on an F-22 or Eurofighter, 40 degrees on an F-117A), and check that you are not losing speed. You should soon see your Vertical Speed Indicator (VSI) start to rise as you become airborne.

Watch your VSI, and make sure you are gaining speed. If you aren't, increase thrust. If this doesn't work, pitch down a little, but make sure you don't start to lose altitude. Your speed should now be well clear of 200 knots, and your altitude should be over 1,000 feet. Retract your undercarriage, and look ahead to avoid any hills or mountains. Now check the direction for your first waypoint. You are ready to begin the mission proper ...

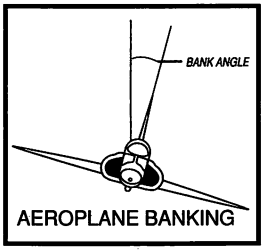
STEADY FLIGHT

To fly at constant altitude in a constant direction, your wings must be level. Check this by looking from the front of the cockpit to the horizon. If your wings are level, then the horizon will be flat. Next, check your VSI. This is the scale in the top right corner of the Head-Up Display (HUD). The line extending up or down from the zero mark shows the change in altitude in feet per second. The box to the left shows the exact value as a number.

To fly at a constant height, you want this reading to be about zero. If it is negative, pull gently back on the stick (or mouse), or tap the 'down arrow' key. You will see the horizon appear to fall as the aircraft's nose rises. How fast this change occurs will depend on how far you moved the joystick (or mouse) or how long you held the key down, and on whether you were in cruise, combat or landing mode. If your VSI has a positive reading, then the same applies, but push the joystick (or mouse) forward, or press the 'up arrow' key.

TURNING

Although turning is only a horizontal change of direction, airplanes can only perform flat (unbanked) turns at low speeds. Normally, the rudders cannot be used simply to turn the airplane's nose toward a different heading. Airplanes have much more control in pitching (up-down rotation), and so turns are made by changing a yawing (sideways turning) motion into one involving pitch. This is done by banking the aircraft, that is, by raising one wing and lowering the other.



AEROPLANE BANKING

To make a turn, you must bank the aircraft so that your desired direction is above your nose. So, push the joystick (or mouse) sideways for a second (or press either the 'left arrow' or 'right arrow' key), then release it. The aircraft will bank and your nose should slowly begin to edge below the horizon as you yaw into the turn. Now, pull back on the joystick (or mouse), or tap the 'down arrow' key, so as to keep your nose level. You are now executing a level turn. The more you bank, the faster you will be able to turn with a level nose.

While turning, you are now using only part of your lift to keep the aircraft up. The rest of your lift is changing the direction of your aircraft's movement. Aerodynamic stability makes sure that your aircraft's nose does not stray too far from this direction at any time. Obviously, as only part of your lift is balancing out your weight, you need more lift in total to stay up. When lift is different to weight, you begin to feel the effect of the resulting acceleration. This is called g-force.

G-FORCE

Nobody feels the effect of gravity. Gravity acts evenly on every particle of your body, so it does not stretch your muscles or compress your bones the way other forces can. However, when you are in the Earth's gravitational field, you will fall unless something stops you. It could be the pavement or the floor of your house, or the chair you are sitting on. Something supports your weight and provides an equal and opposite force to that created by gravity. This you feel. If you are standing on the ground, the force that counteracts your weight does not act evenly: it acts on your feet, and every part of your weight, from your head or your hands or wherever, must be supported by your legs and your feet. So you feel your weight in the sense that you feel the force transmitted from the ground to your feet to your head.

Similarly, if you are in a jet fighter in a tight turn, you feel the force that accelerates your body in the same direction as the airplane. For comparison, we discuss not the actual force of the aircraft on the pilot, which depends on his weight, but the ratio of the force to his weight. So, in level flight, your seat exerts a force equal to your weight, and you are said to experience 1g (pronounced 'one gee'). The same value equals the ratio of the lift force of the aircraft to its own weight.

Accelerating upwards adds to the initial 1g - you feel heavier, so upward acceleration is said to produce 'positive gees', and downward acceleration to produce 'negative gees'. If you were flying upside down, your up is down, so you would now experience -1g ('negative one gee').

Space shuttle astronauts experience up to 3g acceleration. A change of 2g is substantial (one feels twice as heavy under 2g acceleration). Normal human tolerance is about 9g and -3g, with the use of air force g-suits' which help to alleviate the effects. When you are pulling high positive g's, your blood is 'pulled' towards your lower body and away from your head. This can lead to a loss of vision and consciousness, known as 'blackout'. Under negative g's, blood pools in your upper body and head, leading to what is known as 'redout'. Additionally, a fast change in acceleration can cause a very fast g-induced loss of consciousness, called G-LOC.

In TFX, blackout and redout are simulated on screen as graphical effects. In the Realism Menu (see TFX CONFIGURATION on page 50), you can define whether you want these effects disabled, and whether you want a realistic loss of control in blackout.

Landing is a challenge for any new pilot. There is nothing so embarrassing as downing eight MiGs, reducing an enemy runway to rubble and then spreading the debris of your fighter across the length of your own airfield. In TFX, you can always select the auto land feature, but there is no better way to end a mission than a proper manual landing.

First find an airfield. Activate the Instrument Landing System (ILS) HUD mode. If there is a friendly runway nearby you will be given the runway direction and heading. Approach from the correct direction and check your speed. As you near the runway, it should be near the aircraft's stated landing speed (150 knots for the F-117A, about 30 knots slower for the other aircraft). If your speed is too high, try to slow down by reducing engine rpm, and activating air brakes. Your glide path should be around seven degrees descending. You can tell if your glide angle is right by looking at the horizontal bar on the HUD, the Glide Slope Deviation (GSD) bar. When it is in the center, your glide angle is correct. The vertical bar is called the Localizer Deviation (LD) bar, and measures your offset from the middle of the runway.

To the right hand side of the HUD is the Angle of Attack indexer: two arrows around a circle.

- *If your Angle of Attack (AoA) is too high, the top arrow ('caret') will be lit. Increase your speed.*
- *If your AoA is too low, the bottom caret will be lit. Decrease your speed.*
- *If your AoA is correct, the middle circle will be lit.*
- *If your glide slope is correct, but your AoA is not, then your speed is wrong.*

When you make any necessary adjustments, your glide slope indicator may go off-center. You must now readjust your pitch angle with the joystick (or mouse, or keys) to re-center it. This is a continuous process of adjusting glide slope angle and AoA until you get it right.

As your speed falls below 180 knots, lower your landing gear. The drag from your gear will reduce your speed a little. As you slow down and increase your angle of attack, you will notice that speed decreases still further, as a result of AoA. It may actually be necessary to increase thrust again just to maintain your new, lower speed. Do not worry about increasing even to 80 or 90 per cent military power to stay airborne. Be careful though: if you lower your nose, you will speed up again.

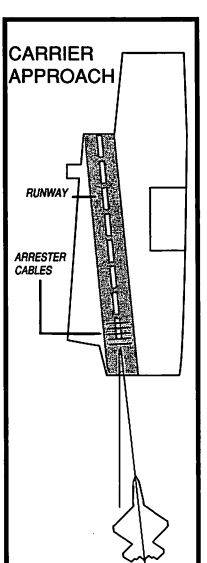
If any of your indicators read badly, if airspeed or altitude is too high as you near the runway, do not attempt to land. Throttle up and fly over the runway, turn around and head back a few miles in the opposite direction, then turn back and try again.

If all goes well, you should arrive at around 50 ft altitude near the start of the runway. Pull back to decrease your glide slope, and watch your VSI. As you touch down, it should read less than 5 ft/s downwards. Increase thrust if necessary to keep speed up as you touch down. When you touch the ground, the ground light to the left-hand side of the HUD should come on. Reduce thrust, and apply your wheel brakes. If you are in a Stealth Fighter, deploy your brake parachute now. Reduce rpm to minimum. Soon, as speed falls, the NW nose wheel steering light left of the HUD will come on. Now use the joystick (or mouse, or the 'left arrow' and 'right arrow' keys) to steer left or right and keep on the runway.

When your speed reaches zero, turn off both engines. You can now end the mission.

CARRIER LANDINGS

Only the F-22 is supposed to land on carriers in TFX. In carrier missions, you fly a different version of the F-22 with an air brake, larger wings and tougher landing gear. Carrier landing with any other aircraft is highly inadvisable, but possible in theory. Follow the instructions as above, and approach the carrier deck from behind at about 20 degrees anti-clockwise from the carrier's forward direction, in order to approach the angled deck straight.



Deploy your arrester hook and aim to touch down in the short stretch of runway between the start of the deck and the arrester wires.

If you hit the deck too quickly, you could bounce right over the wires. If you approach too low, your undercarriage will hit the back of the deck, which will probably spell D-E-A-T-H. If you approach too high, you will miss the hook, which is somewhat less disastrous. If you miss, you will need to turn around to make another pass. For this reason, when you are almost at the wire, turn on your afterburners. If you miss, you don't want to stall. Even with full afterburners, the wire will be strong enough to stop your aircraft.

EMERGENCIES

In landing, many things can go wrong. If your aircraft is already damaged, landing may be made much harder, but attempting a crash landing if possible is always preferable to ejecting and losing your aircraft. If you have engine damage, follow the above procedure as best you can. You may have a much higher VSI reading, and you could damage your gear, but gliding down with both engines out is possible.

Gear damage could prevent you from either retracting or lowering your undercarriage. If you cannot lower the undercarriage, land without. Try to keep the VSI very low, and deploy the brake chute if you have one on touchdown. If things look bad when you hit the ground, eject.

If your wheel brakes are damaged, it will be harder to stop. Deploy the brake chute and air brakes. If you look like careering off the end of the runway, deploy your arrester hook. Every runway has arrester cables for emergency landings.

If you can't actually land on the runway, land near to it. You will be in for a rough ride, but should have a good chance.

DAMAGE

All of the systems in your aircraft are susceptible to damage which affects the appearance of the displays and the behavior of your aircraft. Unless the damage is minor, your priority should be to return home alive and, if possible, with your aircraft intact.

Damage can be inflicted upon your aircraft by AAA, SAMs - even farmers with shotguns! The master warning panel and caution panel will alert you of the damage. If serious damage occurs and you have lost control and power you still may be able to perform an emergency landing and land safely.

The player should only eject as a last resort if the aircraft is on fire and spinning to the ground or a direct missile hit.

The warning display panel on your multi-function display when lit red then that particular system is damaged beyond repair or has failed totally. When the system is yellow this is not permanent damage and can be rectified.

REFUELING

There will come a time when the tiger in your tank is exhausted and you run out of fuel. Fortunately for the forgetful, you are warned that your fuel is running low, in which case the time is nigh to refuel. You have a choice:

** Find a friendly runway and land (where you will also be rearmed).*

** Find a KC Tanker - a refueling aircraft.*

Both methods are not easy and require practice, but it should be noted that mucho bonus points are given for refueling in the air.

A KC Tanker is always full of fuel and on standby above the clouds, so fly high. The tanker usually operates at a service level of 30,000 ft and at a speed of around 300 knots. When you are close enough to the KC Tanker and match its speed, it will release a fuel line - otherwise known as a 'boom'.

• Press the ' key to open your aircraft's refuel access.

REFUELING THE EUROFIGHTER 2000

A fuel feeding tube is located at the front right-hand side of the aircraft (you can see it if you use a Virtual or External View). The trick is to fly so that the tube pokes into the end of the boom released from the left-hand feeding station of the KC-10 Twin Boom Tanker. When you manage this, the boom will lock into place and refueling will automatically occur. The normal fuel feed rate is approximately 300 gallons per minute. The fuel gauge shows the quantity of available fuel.

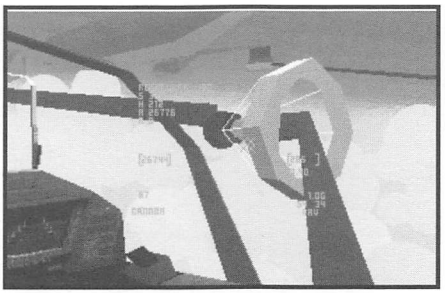


Fig 1: refueling in the Eurofighter 2000

REFUELING THE F-22 AND F-117

The pilot of an F-22 or F-117A has a far easier time refueling. The refuel access is located at the rear of the aircraft, directly behind the cockpit. The KC-135E Single Boom Tanker will push a feeding probe into the back of your aircraft. All you have to do is sit tight and keep your speed, heading and altitude constant.

Fig 2: refueling in the F-22

Section six
combat

Combat has changed dramatically in aerial warfare over the last 60 years but some basic rules still apply. What follows is some straightforward advice which should help you last longer in the skies. But first ...

ARMING YOUR AIRCRAFT

Your aircraft is usually armed automatically, but there are times when you get to choose the equipment, which is where the Aircraft Arming Screen comes into use.

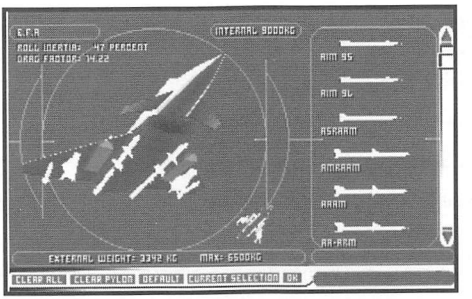


Fig 3: The Aircraft Arming Screen

Your choice of weaponry will depend on the mission profile - there's no point in wasting space carrying air-to-ground weapons when bombing runs are not the order of the day. That said, it's advisable to always carry a couple of defensive air-to-air missiles when flying the F-22 or Eurofighter.

A miniature representation of your aircraft acts as a pointer (note the way that any equipment added is also shown on the pointer). Use the mouse to move the pointer around the screen. Touch the tip of the pointer on the desired option or equipment. (Use the slider to the right of the stock list to view the available equipment.)

- *Press the left-hand mouse button to select an option or 'pick up' a piece of equipment.*
- *Press the left-hand mouse button when the pointer is not touching an option or piece of equipment - the pointer will disappear. You can now use the mouse to rotate the aircraft and view it from all angles.*
- *Press the right-hand mouse button to bring back the pointer.*

Having 'picked up' a piece of equipment, the possible mounting positions are highlighted on the aircraft (if none are shown then the equipment cannot be carried by the aircraft in question or a box will appear to inform you that no pylons are available for that weapon). Move the equipment to the desired mounting. Note the internal and external weight limitations.

- *Press the left-hand mouse button to place the equipment on the mounting.*
- *Press the right-hand mouse button to place the equipment back in stock.*

CLEAR ALL Select this to remove all equipment from the aircraft.

CLEAR PYLON Select this to change the pointer into a red 'eraser'. Now select the equipment (on the aircraft) you wish to remove. Ensure that you have a clear view of the aircraft's underside, to make the removal of equipment easier.

- *Press the right-hand mouse button to bring back the pointer.*
- *Press Escape to reset previous pylon selection.*

If you don't want to call the shots you can always let the TFX program make the choice of weapons for you ...

DEFAULT Select this to load your aircraft with a selection of appropriate equipment.

CURRENT SELECTION Select this to view the underside of the aircraft - and all equipment in position.

OK Select this to proceed when you are happy with your choice of equipment.

AIR-TO-AIR COMBAT

There are four key ways to keep tabs on the position of enemy units: the map, radars, the HUD and visual contact.

The aircraft which is first detected by another is usually the victim. Your superior radar capabilities should give you the edge, so ensure that your weapons are armed and ready, and that your speed, heading and altitude are good. Don't rely solely on the radar though - use your eyes to scan the skies thoroughly at all times.

Always approach the target from his blind spot - his rear quarter - unless you have long range stand-off weapons such as AMRAAM or AAM, in which case you should fire them at high speed (Mach 2 upwards) for maximum kinetic energy at launch.

If the element of surprise is lost, or was never possible, then manoeuvrability will be the next deciding factor. The pilot who can out-turn and gain the best advantage will be victorious, especially in close range combat.

Fighter jets move so fast that it is hard to aim any weapon at an enemy unless you are directly behind your target. The aim of any close dogfighting is to get behind your enemy's tail ('on his six') and keep him in front of you. If he can turn faster than you, it will be much harder to do this.

AIR-TO-AIR TACTICS

Using available data from AWACS or your BVR radar, close in on any potential bandit from a safe position. Long range tracking will inform you of his speed, altitude, heading and range from you.

20-60 MILES Use long range semi-active 'fire and forget' radar-guided missiles.

10-20 MILES Use medium range radar-guided missiles.

1-10 MILES Use short range radar-guided or infrared heat seeking missiles.

1 MILE OR LESS Use the cannon. Missiles can find it difficult to launch, track and arm in time.

AIR-TO-GROUND COMBAT

You can attempt to manually use your cannons and missiles to destroy ground-based targets, but your best bet is to take advantage of the Laser Target Designator wherever possible.

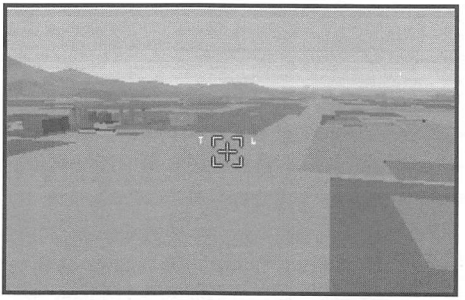


Fig 4 : the Laser Target Designator is active

This nifty piece of kit allows you to accurately determine a GBU bomb's destination to within inches of a target. It has a 100 mile radius range (but that doesn't mean that the bomb will travel that far) and is best used from an altitude of around 6,000 ft.

The target appears on your radar. Soon you will make visual contact. Prepare yourself ... Ensure that the aircraft is on a level course before engaging the LTD - you don't want to end up crashing.

- *Press the backspace key to select air-to-ground mode.*
- *Press the Z key to activate the Laser Target Designator.*

The view will change to show that of the Laser Target Designator (Fig 4). The flashing 'T' above the crosshair shows that you have yet to select a target.

A target is selected by directing a laser beam to illuminate it.

- *Press the arrow (Cursor) keys to move the crosshair.*
- *Press the < key to zoom in and the > key to zoom out - up to 10 times magnification and down to zero.*
- *Press the Z key to reset the zoom to default.*
- *Press the Z key when the target is shown inside the lock.*

The 'L' above the crosshair will flash instead of the 'T', to show that you have locked on to a target. Are you sure that's close enough?

- *Press the X key to break the lock.*
- *Press any function (view) key to see the aircraft.*

With the lock determined, a 'funnel' (invisible to the eye) is created between your aircraft and the target. The computer-controlled bomb will attempt to stay within the boundaries of the funnel in order to hit its target. You may now launch a bomb.

DEFENSIVE MEASURES

MISSILE EVASION TECHNIQUES

All the major air forces of the world have infrared heat seeking missiles, which lock on to your exhaust pipe, or radar-guided missiles which aim for your radar-emitting cockpit and nose cone. All are the most dangerous threats you will meet in the skies.

AVOIDING INFRARED MISSILES You will know when an infrared missile is heading straight for you because the missile warning panel will be flashing 'IR LCK' and 'LCH' like crazy. This is not a good time to panic. Drop a few decoy flares in the hope that they will appear more appealing to the missile than your engines.

Ensure that your afterburners are off then perform a hard brake and turn sharply into a defensive position. An infrared missile has a narrow field of vision and can easily lose its lock once your aircraft - its rear quarter in particular - is out of sight. A last minute evasion may avoid the missile because it's heading toward you at such a high speed and has no time to turn. However, be warned that the latest infrared missiles are persistent and will chase you until their fuel runs out.

AVOIDING RADAR-GUIDED MISSILES These are tricky blighters, regardless of whether they are launched in the air or from the ground. Dropping chaff will cloud a radar-guided missile's vision giving you precious split-seconds to perform a defensive break and get the hell out of there. Unfortunately, it's far harder to break a radar-guided missile's lock than it is an infrared's.

The other option open to you is to use Electronic Counter Measures. The incoming radar-guided missile will weave erratically as its guidance system is screwed up by the powerful electronic pulses from your ECM pod.

The previous section of this manual deals with selection and use of weapons, but there are some special aspects of manoeuvrability which apply mainly to air-to-air combat.

Fighter jets move so fast that it is hard to aim any weapon at an enemy unless you are directly behind your target. The objective of any close dogfighting is to get behind your enemy's tail ('on his six') and keep him in front of you. If he can turn faster than you, it will be much harder to do this. There is an equation for turn rate which will help you to win:

$$TURN\ RATE = a / V$$

where ***a*** is acceleration, which increases with the number of g's you are pulling and ***V*** is speed.

So a higher g value and a lower speed will give you the best rate of turn.

There is a limit to the number of g's a given fighter can pull for any length of time in a level turn. In fact, there are three limits:

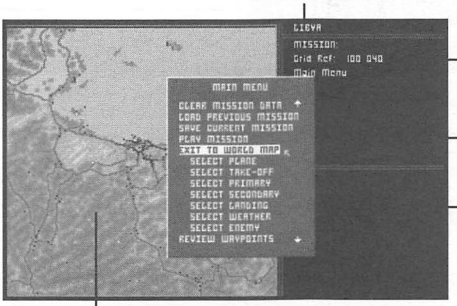
THE LIFT LIMIT The lower your speed, the less lift you can have. If you are using all of your lift just to stay up, you cannot turn. So the lift limit increases from 1g at the stall speed to ever higher values.

THE POWER LIMIT Lift causes more drag, and drag slows you down unless you increase thrust to compensate. You only have so much thrust available, and at high speeds, all your thrust is used just to maintain those speeds in level flight. Therefore, the power limit is more significant at higher speeds.

THE TOLERANCE LIMIT The aircraft and the pilot can only sustain so much stress before respectively falling apart or blacking out. Usually the aircraft has a higher tolerance than the pilot, who can only stand about 9g. Some aircraft, like the F-117 A, have a lower structural limit.

making missions with UN Central Command

It couldn't be simpler. Having selected this option you need to pick one of the four possible hot spots from the world map - just as you would for most other missions. Note that due to diplomatic pressure, the South Atlantic environment is not available. UN Central Command is now at your disposal ...



THE MAIN MENU

All UN Central Command options are chosen from here. As you will see, keyboard short-cuts are available for some options. Select the arrows on the right-hand side of the Main Menu to reveal options above and below those shown.

CLEAR MISSION DATA Select this followed by 'yes' to wipe the slate clean.

LOAD PREVIOUS MISSION From the hard disk. Pick the mission's filename from the list shown or select 'cancel'.

SAVE CURRENT MISSION To the hard disk. Pick a slot, amend or type a new description if necessary, then press the Enter key to save the mission.

PLAY MISSION You must save it first (you will be reminded if the mission has not been saved).

EXIT TO WORLD MAP Select this if you wish to pick another hot spot. You will be prompted if your mission has not been saved.

BUILDING A MISSION

You must use all of the following 'SELECT' options to construct a mission. A tick next to the 'SELECT' options shows that it has been dealt with.

SELECT PLANE Choose any one of the three from the menu presented.

SELECT TAKE-OFF Well you have to start somewhere ... When this option is selected, all possible takeoff points on the map will flash. Use the mouse to move the crosshair around the map.

- *Press the right-hand mouse button at any time to return to the Main Menu.*
- *Press the left-hand mouse button to call up information on the dot beneath the crosshair.*

The identity and map co-ordinates of the dot below the crosshair are given. You can now select the dot as a takeoff point.

SELECT PRIMARY There are eight possible Primary Target types: Maritime, Docks, Factories, Power Stations, Bridges, Airfields, Military HQs and Oil Targets. From the list, pick the targets you wish to highlight on the map (they will flash). Note: it's wise not to choose too many targets types at once as it can get confusing. The process of selecting Primary Targets is the same as that for choosing a takeoff point.

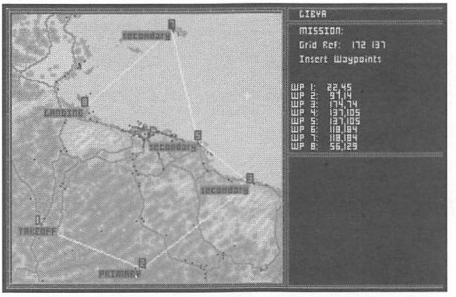
SELECT SECONDARY Up to five targets are selected in the same way as the Primary Targets.

SELECT LANDING You have to land somewhere once your mission is complete. Select a landing spot in the same way as you chose a takeoff point.

SELECT WEATHER Choose from the menu presented any one of the following: 'DAY CLEAR', 'DAY CLOUDY', 'NIGHT CLEAR', 'NIGHT CLOUDY', 'STORMY' and 'TWILIGHT' to determine the general weather conditions.

SELECT ENEMY Not specific craft, you understand, but the intensity of enemy presence. Choose 'LIGHT', 'MEDIUM' or 'HEAVY' from the menu presented.

REVIEW WAYPOINTS With all aspects of the mission in place, it's wise to double check the waypoint situation. Select this option to review the numbered waypoints (you know, the electronic markers used by the auto pilot) step-by-step, from takeoff through primary and secondary targets to landing. You will be prompted if any one of the mission requirements is missing.



Maybe you'd like to add, remove or modify a waypoint? No problem ...

Use the right hand mouse button to go to Waypoint menu

- *Insert mode.*
- *Delete mode.*
- *Modify mode.*
- *KC Tanker mid-air refueler.*
- *EXIT the waypoint review and return to the Main Menu.*

Use the mouse to move the crosshair over a waypoint.

- *Press the left-hand mouse button to select the waypoint.*
- *Press the left-hand mouse button again to either 'pick up' the waypoint or delete it, depending on the chosen mode.*

Use the mouse to move the new or existing waypoint.

- *Press the left-hand mouse button to place the waypoint.*
- *Press the right-hand mouse button to de-select the waypoint.*
- *Play Mission: Press enter to play mission.*

TEXT AT CURSOR Basically, information on the dot beneath the crosshair is shown in the top right-hand corner of the screen.

VIEW 3D Or 2D for that matter. Toggle between a static Earth Net Satellite plan view or a rotating three-dimensional view of the area.

- *Press the V key to call up a satellite view of the area.*
- *Press the left-hand mouse button or the 5 key on the numeric keypad to toggle between the plan view and the rotating three-dimensional view.*
- *Press the right-hand mouse button or the Esc key to quit the satellite view and return to the standard maps.*

To move the satellite around the map ...

- *Press the 8 key on the numeric keypad to move the view up by half a screen.*
- *Press the 2 key on the numeric keypad to move the view down by half a screen.*
- *Press the 4 key on the numeric keypad to move the view left by half a screen.*
- *Press the 6 key on the numeric keypad to move the view right by half a screen.*

Note that the mouse can also be used to move the view.

The satellite's altitude is adjusted in large steps as follows ...

- *Press the 1 key to view the area from 800 feet (minimum altitude).*
- *Press the 2 key to view the area from 1,600 feet.*
- *Press the 3 key to view the area from 3,200 feet.*
- *Press the 4 key to view the area from 6,400 feet.*
- *Press the 5 key to view the area from 8,000 feet.*
- *Press the 6 key to view the area from 16,000 feet.*
- *Press the 7 key to view the area from 32,000 feet.*
- *Press the 8 key to view the area from 64,000 feet.*
- *Press the 9 key to view the area from 96,000 feet.*
- *Press the 0 key to view the area from 128,000 feet (maximum altitude).*

ZOOM MAP IN/OUT The map as it stands provides a useful overview of the area, but it's easier to select targets with a closer look. Note that this zoom function does not work with the satellite map.

- *Press the Z key to toggle the zoom IN or OUT.*

MAP - PHYSICAL A relief map of the area - with all targets in place.

- *Press the F1 key to select the Physical Map.*

MAP - AWAC An electronic map of the area - as supplied by the AWAC - with all targets in place.

- *Press the F2 key to select the AWAC Map.*

MAP - POLITICAL Shows clearly the country boundaries - with all targets in place.

- *Press the F3 key to select the Political Map.*

Section eight

control summary

Sure, there are dozens of key controls to learn - more than any keyboard overlay could conveniently accommodate (hence its omission from this package) - but the basic controls are simple enough. The rest you will learn through bitter experience ...

BASIC CONTROLS

The aircraft climbs, dives and banks left and right via the mouse, a joystick, or the arrow (cursor) keys on your computer's keyboard.

The left-hand mouse button is used to increase thrust, and the right-hand mouse button is used to decrease thrust.

ENGINES All three aircraft flown in TFX are powered by two engines.

- *Press the + key to increase the engines' thrust.*
- *Press the - key to decrease the engines' thrust.*
- *Press the [key to ignite or shut down Engine 1.*
- *Press the] key to ignite or shut down Engine 2.*

AFTERBURNERS Just the thing for an instant burst of extra power. The Eurofighter 2000 and the F-22 Superstar have four stages of afterburner strength while the F-117A has - oh dear - none. Afterburners are heavy on the fuel, so use them frugally.

- *Press the * key on the numeric keypad to increase the afterburner by one stage.*
- *Press the - key on the numeric keypad to decrease the afterburner by one stage.*
- *Press the / key on the numeric keypad to turn off the afterburner.*

AUTO PILOT Once the auto pilot is engaged, there are four modes of operation available. For further details see THE AUTO PILOT on page 25.

- *Press the A key to toggle the auto pilot ON or OFF.*
- *Press the 7 key for auto pilot mode 1.*
- *Press the 8 key for auto pilot mode 2.*
- *Press the 9 key for auto pilot mode 3.*
- *Press the 0 key for auto pilot mode 4.*

AUTO LAND Sit back, take it easy and let your on-board computer fly you to the nearest friendly runway or your final waypoint and perform the landing for you.

• Press and hold an Alt key then press the L key to activate the computer-controlled landing.

PANIC RECOVERY BUTTON Look, it happens to the best of us in combat situations. When the going gets a little too heavy and you lose it - and control of your aircraft - and find yourself plummeting to the ground, this computer-controlled function will do its best to put you straight.

• Press the tab key to activate the computer-controlled recovery.

LANDING SYSTEMS

INSTRUMENT LANDING SYSTEM (ILS) A useful aid for landing your aircraft. For further details, see THE INSTRUMENT LANDING SYSTEM on page 23.

• Press the I key to turn on the ILS. Once the ILS mode has been selected by pressing "I" again, it is possible to find runways easier by pressing "m" for map view and any available runways or airfields will flash white on the map.

LANDING GEAR It's best to land with it down! Note that the Landing Gear may be damaged if it's down when your aircraft is flying at high speed.

• Press the G key to toggle the landing gear UP or DOWN.

BRAKES Each aircraft flown in TFX has three brake systems. The brake parachute works either on the ground or in the air but is ideally used to land on a short runway. Remember to turn off your Wheel Brakes when powering up to takeoff speed - they may be damaged if the rpm exceeds 70 per cent.

• Press the W key to toggle the wheel brakes ON or OFF.

• Press the B key to toggle the air brake ON or OFF.

• Press and hold an Alt key then press the B key to deploy the brake chute.

• Press and hold the left-hand shift key then press the B key to release the chute.

ARRESTER HOOK Located at the rear of the aircraft and used to catch and Arrester Wire - either on aircraft carriers or normal runways (in emergencies) - in order to slow the aircraft to a halt (for further details see LANDING on page 30).

• Press the H key to toggle the arrester hook UP or DOWN.

THE HEAD-UP DISPLAY The HUD is basically a reflection of the aircraft's main instrumentation reflected onto the windshield, so saving pilots the inconvenience of taking their eyes off whatever's ahead. TFX also features a fundamental helmet-based HUD. For further details, see THE HEAD-UP DISPLAY on page 18.

• Press and hold an Alt key then press the H key to toggle the HUD ON or OFF.

TARGET LOCK Your aircraft can track up to 10 targets at once.

• Press the C key to toggle the lock between targets.

THE MAP A complete overview of your surroundings. Different colored dots represent enemy and friendly installations and airborne craft. For further details, see THE MAP on page 14.

• Press the M key to toggle the map ON or OFF.

THE MULTI-FUNCTION DISPLAYS Each aircraft has three MFDs from which a wealth of information is easily accessed. For further details, see MULTI-FUNCTION DISPLAYS on page 14.

• Press the 1 key to cycle through MFD1.
• Press the 2 key to cycle through MFD2.
• Press the 3 key to cycle through MFD3.

TOGGLE TARGET VIEWS Accessed through MFD1.

• Press the N key to switch between target views.

THE MFD RADAR A simplified overview of the friendly and enemy units in the vicinity. For further details, see THE MULTI-FUNCTION DISPLAY RADAR on page 16.

• Press the R key to switch the radar range between 50 miles, 30 miles, 10 miles and 2 miles.

MESSAGES Communications from AWACS, control towers, your on-board computer and other pilots appear frequently. Take note of what's said.

• Press the L key to display the last displayed message.

INFRARED NIGHT SIGHT Yes, you too can see in the dark without the aid of carrots.

• Press and hold the left-hand shift key then press the N key to toggle the infrared night sight ON or OFF.

WEAPON SELECTION

Select the weapon type: air-to-air, air-to-ground or cannons. Note that the HUD will change to reflect the selection.

- *Press the Enter key to select air-to-air weapons.*
- *Press the Enter key again to switch between the different types of air-to-air missiles.*
- *Press the backspace key to select air-to-ground weapons.*
- *Press the right-hand Control key to select cannons (and change the HUD to navigation mode).*
- *Press the spacebar to fire the selected weapon.*

THE LASER TARGET DESIGNATOR Used to guide GBU air-to-ground missiles to their targets. For further details, see USING THE LASER TARGET DESIGNATOR on page 38.

- *Press the Z key to activate the Laser Target Designator.*
- *Press the arrow (cursor) keys to move the crosshair.*
- *Press the < key to zoom in and the > key to zoom out.*
- *Press the Z key when the target is shown inside the lock.*
- *Press the X key to break the lock.*
- *Press any function (view) key to see the aircraft.*

CHAFF Literally little pieces of tin foil which confuse the hell out of radar-guided missiles. Note that chaff is always in limited supply, regardless of the play option.

• *Press the Insert key to release chaff.*

FLARES Used to confuse heat-seeking missiles. Note that flares are always in limited supply, regardless of the play option.

• *Press the Delete key to release flares.*

ECM Electronic Counter Measure. The aircraft lights up like a Christmas tree to every radar and tracking device within 200 miles so use it only when you have been detected. It confuses any radar tracking devices. ECM works in two ways: it gives inbound radar-guided missiles a nervous fit - as they attempt to home in they shake violently and cannot manoeuvre fast enough. It also prevents or makes it more difficult for the enemy fighter to lock a missile on to you.

• *Press the E key to emit ECM.*

STEALTH Effectively the opposite of ECM. Your aircraft becomes 'passive', receiving but not emitting signals, which makes it almost invisible on radar.

• *Press the S key to activate stealth mode.*

EJECT When it all goes horribly wrong and death is on line, why settle for anything less than survival? (Well, there is a great danger of being captured if you eject over enemy territory.)

- *Press the Esc key TWICE to eject from your aircraft. Note that your descent can be controlled to a limited degree.*

Please note: eject wisely. Should you decide to ditch the aircraft in a situation which is not life threatening, you risk Court Martial proceedings for destroying $100 million worth of hardware.

JETTISON Your aircraft's fuel tank and air-to-ground stores can become a liability in certain situations. For example, when using the Military Specification flight model, the added weight makes your aircraft more cumbersome in air-to-air combat. With the loss of weight you gain maneuverability. Just try not to drop your load on innocent civilians.

- *Press and hold an Alt key then press the J key to jettison your aircraft's fuel tank and air-to-ground stores.*

REFUEL ACCESS It needs to be open if you are to refuel in mid-air. For further details, see REFUELING on page 33.

- *Press the ' key to open your aircraft's refuel access.*

WEATHER CONDITIONS Sometimes you need to know whether the weather is good or bad.

- *Press an Alt key then press the W key to call up the weather conditions in the Internal Communications area.*

PAUSE Maybe you want to answer the door or the call of nature ...

- *Press the P key to freeze the action.*
- *Press any key to resume play.*

TFX CONFIGURATION Adjust pertinent play details (for further details see TFX CONFIGURATION on page 2).

- *Press the ` (above tab key) key to call up the preferences screen.*

VIDEO RECORDER A state-of-the-art system used to record the action as you see it. Any footage of 3D action will be broadcast immediately after the mission at a special television press conference - so make it look good!

- *Press and hold the left-hand Alt key then press the V key to toggle the video recorder ON or OFF.*

Note: there may be a slight pause as the video footage is written to the hard disk. If hard disk space is limited, keep the footage short and sweet.

ACCELERATED TIME Lengthy flights across barren terrain can prove a real drag. To compensate for this, time itself can be increased by a factor of 10. Note that everything in the TFX world will speed up - including your aircraft's handling and the enemy's movements!

- *Press the T key to toggle accelerated time ON or OFF.*

QUIT Without dying - but only if your mission is complete.

- *Press and hold the left-hand shift key then press the Q key to quit play.*

An unprecedented number of possible viewpoints are on offer ...

INTERNAL VIEWS From the cockpit.

- *Press the F1 key for a fixed forward view - with full instrumentation.*
- *Press the Page Up key to move the cockpit UP.*
- *Press the Page Down key to move the cockpit DOWN.*
- *Press the F2 key to swing the view to the left (in 60 degree steps).*
- *Press the F3 key to swing the view to the right (in 60 degree steps).*
- *Press the F4 key to look behind you.*
- *Press and hold the right-hand shift key and then press the F1 key for a full forward view - without instrumentation.*

VIRTUAL COCKPIT VIEWS A step further than the standard internal views ... You can view the cockpit as though you were sitting in it for real. Sure, the control panel cannot be read, and it can all prove a little disorientating at first, but the benefits will become clear ...

- *Press the F10 key for a Virtual Cockpit View.*
- *Press and hold the right-hand shift key then press the arrow (cursor) keys to look around the cockpit.*

EXTERNAL VIEWS There's nothing more exhilarating than viewing your aircraft's performance through an external 'camera'. Your aircraft's altitude, speed and heading are shown in a panel at the bottom of the screen.

- *Press the D key to toggle the flight details ON or OFF.*
- *Press the F6 key for a 'fly-past' view of your aircraft.*
- *Press the F5 key to view the aircraft from behind.*
- *Press the F5 key a second time to pull the view back. You can now pan the 'camera' around the aircraft.*
- *Press and hold the right-hand shift key then press any of the following keys...*
- *Press the arrow (cursor) keys to pan the 'camera' around the aircraft.*
- *Press the End key to zoom out.*
- *Press the Home key to zoom in.*
- *Press the Page Up key to rotate the view to the left.*
- *Press the Page Down key to rotate the view to the right.*

WEAPON VIEWPOINTS Some of the most impressive views are those from behind or inside weapons.

- *Press the F8 key to follow cannon-fire or a missile.*
- *Press the F8 key TWICE for an infrared missile's-eye view.*

ENEMY VIEWPOINTS It's kinda handy (and fun) to keep tabs on your position relative to the enemy's.

- *Press the F7 key to view your aircraft and the enemy airborne or ground-based craft you are tracking - on the same screen, no less.*

TARGET VIEW An external view of the area near your selected target, be it airborne or ground-based. This view also shows your aircraft's refuel access when refueling or the runway or the carrier when using the ILS.

- *Press the F9 key for a target view.*

appendix one

mission profiles

It is often thought that fighter aircraft tackle seven distinct types of mission. They are as follows:

INTERCEPTION You have been scrambled to meet incoming hostiles. Stop them at all costs.

AIR SUPERIORITY Win control of the sky by taking out all airborne enemy craft in the area.

ANTI-ARMOUR Use multiple 'bomblettes' against heavily-armoured tanks and vehicles.

CLOSE AIR SUPPORT Provide air cover for ground-based troops.

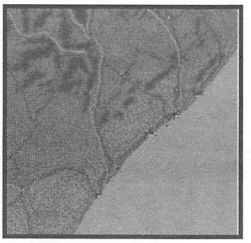
INTERDICTION Destroy a fixed ground target, be it a bridge or a factory. This is the most common mission you will encounter. Most missions for the F-117A are of the Interdiction variety.

DEFENSE SUPPRESSION Destroy ground-based targets such as SAM radars and SAM sites.

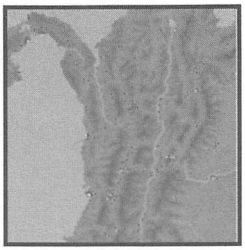
MARITIME A battle over the water against ships or carrier-based operations.

TFX caters for all seven mission profiles. Be warned that often you will need to complete more than one mission profile at the same time.

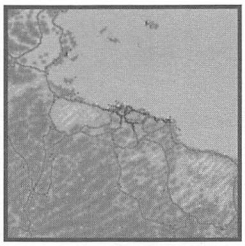
The TFX environment is a vast, fully realized portion of the world's potential and actual trouble spots. All terrain is accurately mapped and the world as a whole remains consistent between missions (so anything destroyed stays destroyed). The TFX environment is split into five distinct 'climes' which incorporate specific missions to test your mettle.



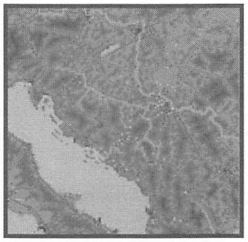
SOMALIA Operation Restore Hope II. Famine is rife once again and General Mohammed Aideed's warlords are on the war-path. It's time for the UN to sort out this horrific situation once and for all. Can you crush the oppressors to allow relief convoys to move in?



COLOMBIA The Drugs War. The government has been ousted and civil war is raging between the new force (the drug cartels) and those loyal to the former regime. Normally the UN doesn't get involved in such internal messes, but this time the possibility of a drugs explosion has far-reaching, world-wide consequences.



LIBYA Saddam Hussein has denied access to inspectors in search of proof of nuclear weapons production. It's down to the UN to make him see sense.

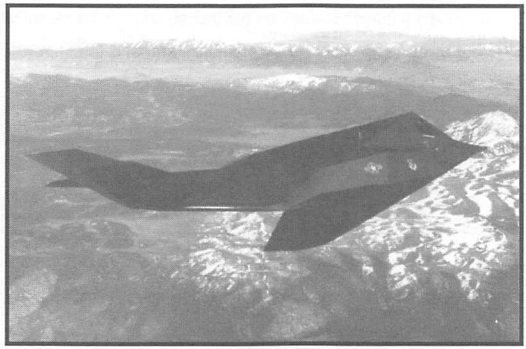


YUGOSLAVIA The Balklands is still the tinderbox of Europe, and war has exploded again as the armies of Serbia and Croatia attempt to carve up Bosnia and besiege the UN-declared safe havens.

THE SOUTH ATLANTIC Somewhere around South Georgia ... In 1999 the biggest oil discovery the world has ever seen has resulted in neighboring countries clambering to make claims. England and Argentina have sovereign rights but the South Americans want the oil so badly they will even go to war for it. To make matters worse, a ship carrying enough plutonium to produce 200 heavyweight nuclear bombs has gone missing in the area. The UN have been called in to find out what's going on ... and maybe wage battle against whatever lies in wait.

appendix two

elements of an airplane



MAIN SURFACES

WINGS The wings are there to create lift. In a fighter, they are usually swept back to reduce drag at high Mach numbers.

TAILPLANE Or horizontal tail. Stabilizes the aircraft, by creating a nose down moment at high angles of attack. It is also used to control pitching (see ELEVATORS).

TAILFIN Or vertical tail, stabilizes the aircraft, by creating a yawing moment when the aircraft is side-slipping. It is also used for steering (see RUDDER).

CONTROL SURFACES

AILERONS These are parts of the wing on the trailing edge, hinged so as to be mobile, which are deflected in opposite directions to roll the aircraft, by increasing lift on one wing and decreasing it on the other.

ELEVATORS These are usually located on the tailplane. Often, they are the tailplane. The elevators create a pitching moment to change angle of attack or maneuver the aircraft.

RUDDER This is usually a hinged surface on the trailing edge of the tailfin, which is used to steer the aircraft at low speed and to co-ordinate turns and to control rolling at high angles of attack.

HIGH LIFT DEVICES

FLAPS Like ailerons, these can be on the trailing edge of the wing, but are used to increase lift overall and increase the maximum lift. They are used to reduce take-off and landing speed and distance. Deployed flaps increase drag, and so are retracted at higher speeds. Many airplanes have leading edge flaps which increase maximum lift, although they slightly decrease the lift at any given angle of attack.

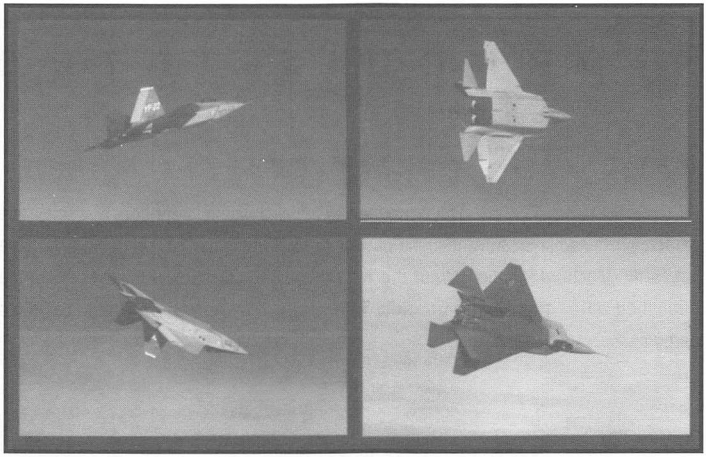
SLATS These extendible devices take the place of leading edge flaps, delaying stall at high angles of attack.

The jet engine is a device which takes in air, propels it to high speed, and ejects it at the back, producing thrust. There are two main kinds:

TURBO-JET Takes in air at the front, compresses it, and burns fuel inside a combustion chamber. The hot, high speed jet of gas drives a turbine (hence 'turbo'), a windmill-like rotor at the back, which powers the compressor, which is like a many-bladed propeller, and leaves from the nozzle, accelerating to supersonic velocities.

TURBO-FAN Puts only a proportion of the compressed air into the combustion chamber - the rest flows around the outside of the combustion chamber and meets with the jet flow after the turbine. A turbo-fan is more efficient than an equivalent turbo-jet, but produces less thrust.

Almost all modern jet engines are turbo-fans, but the new high thrust engines which will power the F-22 and Eurofighter 2000 are turbo-fans with low bypass ratios, meaning that most of the air flows through the combustion chamber.



AFTERBURNER For extra thrust in certain situations, more fuel is put into the mixture than can be burned in the combustion chamber. When it meets the outside air in the nozzle, the fuel is lit, producing very high thrust, at the expense of high fuel consumption. The system which does this is called an afterburner, and the effects can often be seen as a visible flame coming from the nozzles.

Or landing gear. A set of wheels put down for landing to support the aircraft on the runway. It must be retracted at higher speeds in the air as it causes drag and is not designed for high speed flight.

the elements of an airplane in TFX

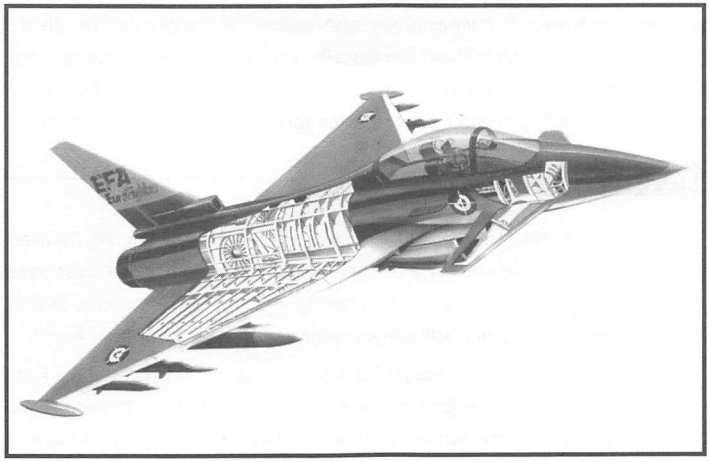
All of the above elements are modeled in TFX in terms of their effects on the force and turning characteristics of the airplanes. For example, moving the joystick (or mouse) up and down (or pressing the up and down arrow keys) adjusts the elevator position. This affects the angle of attack, which in turn affects wing lift and thus maneuver the aircraft.

appendix three

the TFX aircraft

All three aircraft in TFX are high performance vehicles with a great deal of money and research invested in them. At the time of writing, the Eurofighter 2000 and the F-22 have yet to fly. Much information about the F-117/A is still classified. However, from the published data, it has been possible to estimate key aspects of each vehicle's performance.

EUROFIGHTER 2000



SUPPLIER	Eurofighter Jagdflugzeug GmbH
TYPE	Light, highly agile, foreplane configured air-to-air fighter Secondary air-to-ground capability
	Some stealth characteristics
ENGINES	2 Eurojet EJ 200 Afterburning Turbofans
SEA LEVEL RATED THRUST	90 kN (Afterburning)
	60 kN (Military Power)
THRUST VECTORING	+/- 20° (Vertically)
DIMENSIONS	
LENGTH	47.85 ft.
HEIGHT	13.2 ft.
WING AREA	540 sq. ft.
WING SPAN	34.65 ft.
FOREPLANE AREA	26 sq. ft.
WEIGHTS	
OPERATING EMPTY	21,450 lbs.
MAX. TAKEOFF	46,200 lbs
INTERNAL FUEL	8,800 lbs.
EXTERNAL STORES	14,300 lbs.
ENVELOPE	
MAX. LEVEL SPEED	Mach 2 (At Altitude)
TAKEOFF SPEED	135 knots *
LANDING SPEED	125 knots *
CRUISING SPEED	510 knots *
CRUISING ALTITUDE	46,000 ft *
TAKEOFF/LANDING RUN	500 m
COMBAT RADIUS	500 nm (nautical miles)
STALLING SPEED	99 knots (Sea Level) *
MAX. AoA	22.5°
G LIMITS	9, -3

* Own Estimates

Handling is 'carefree', with many automatic safety features: landing gear auto-retracts at high speed, angle of attack is limited automatically, and a 'panic button' initiates recovery to level flight in emergencies. Leading edge slats and trailing edge flaps are adjusted automatically for optimum benefit. External stores increase drag, roll inertia and mass.

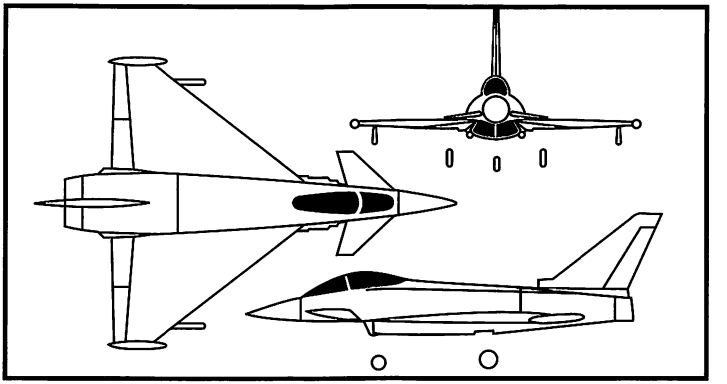
DEVELOPMENT HISTORY

Since the war, the price of developing a combat aircraft has steadily risen, with the effect that fewer and fewer companies have been involved in their production, and almost none have been built recently without government funding. In Europe, only France and Sweden have continued to build fighters, with often state-owned companies surviving on exports.

Some European countries have bought US airplanes, like the Phantom and the F-16. Others have joined forces. Companies from the UK, Germany and Italy formed Panavia in the 1970s to develop the Tornado strike aircraft for the three nations. The lack of a dedicated fighter has led to the Tornado's adaptation to serve in the air-to-air role, but the Panavia partners - Aeritalia, British Aerospace and MBB - seeing in 1982 that the requirement for dogfighting capability in a modern air force would continue, proposed a new one-man fighter, the Agile Combat Aircraft (ACA), a canard-configured, twin-finned aircraft.

The ACA was never given the go-ahead, but in 1983, France, Germany, the UK, Italy and Spain outlined a joint requirement for a new combat aircraft, to enter service in the 1990s. It was to be called the European Fighter Aircraft (EFA). Towards its development, the British government funded a technology demonstration aircraft, the Experimental Aircraft Programme (EAP), built by BAe and Aeritalia. Not strictly a prototype, the EAP was a research vehicle for the technologies involved in the EFA programme.

France withdrew from the EFA programme in 1985, and in 1992, Germany threatened to do the same but was convinced by the remaining nations to remain, although the German aircraft will lack some of the systems present in the other airplanes, and more of the funding will come from industry. Following the four-nation meeting on December 10th, 1992, the name EFA was dropped ... The aircraft was to be called the Eurofighter 2000.



The Eurofighter 2000 has a canard configuration, meaning that the 'tail' is mounted forward of the main wings. This is inherently unstable, for the following reason:

In a normal fighter, the all-moving tail is used to pitch the aircraft up and down. Deflecting the tail down gives it a negative angle of attack, and thus a downward force, which turns the whole aircraft nose-up. As this happens, the initial deflection of the tail is offset by the overall motion of the aircraft, and so the pitching force is reduced, as the aircraft moves to a higher, stable angle of attack.

If the tail is at the front, it is turned upwards to create a nose-up pitch, and the resulting motion increases the force on the canard, so then in order to stabilize the higher AoA, the canards must be deflected entirely the other way, or the whole aircraft will pitch up into a stall.

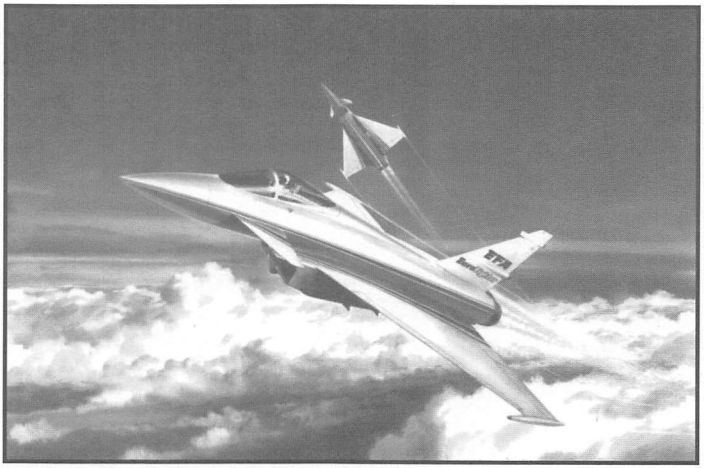
The advantages of the canard are that it is never in the wake of the wing, and so retains its effectiveness at high angles of attack. A canard configured airplane can have less afterbody (tail-end) drag than an equivalent aft-tailed version. The canard can be smaller than a tail would need to be, as demonstrated in the 2000's tiny 25.9 sq. ft. canard area.

Only now, with the advent of digital flight control systems (DFCS) can the canard be used as a means of control. Even so, a spokesman for the company which pioneered unstable, computer controlled fighters is reported to have said: "In the view of General Dynamics, the optimum location of a canard is on somebody else's airplane."

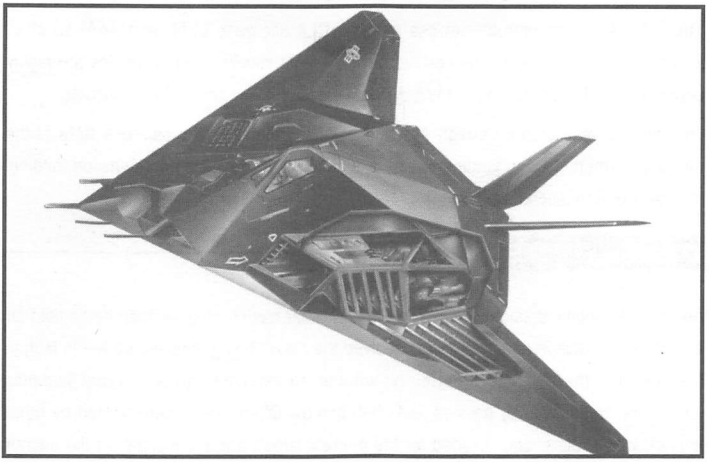
In spite of this obvious difference, detractors have described the Eurofighter 2000 as 'F-16 Plus'. In the same weight class as General Dynamics' (now Lockheed Fort Worth) successful fighter, the Eurofighter has a much larger wing, at 165 ft., and with two 90 kN (kilo Newton) engines, compared to F-16's single 122 kN, the Eurofighter has more power for maneuvering.

The Eurofighter will have a variable shape mission adaptive wing (MAW), using slats and flaps.

The fighter will have a 'glass cockpit' of modern design, with three MFDs. Most versions will have a helmet mounted targeting system, and direct voice input (DVI) for non-critical functions.



LOCKHEED F-117A STEALTH FIGHTER



SUPPLIER	Lockheed Advanced Development Company (LADC)
TYPE	Very low radar cross-section night attack aircraft
	Low IR emissions
ENGINES	2 Non-Afterburning General Electric F404-GE-F1D2 Turbofans
SEA LEVEL RATED THRUST	48 kN (Military Power)
DIMENSIONS	
LENGTH	66.26 ft.
HEIGHT	12.47 ft.
WING AREA	1,143.72 sq. ft.
WING SPAN	43.56 ft.
WEIGHTS	
OPERATING EMPTY	29,937.6 lbs.
MAX. TAKEOFF	52,390.8 lbs.
INTERNAL FUEL	17,463.6 lbs
INTERNAL STORES	4,989.60 lbs.
ENVELOPE	
MAX. LEVEL SPEED	Mach 0.85
TAKEOFF SPEED	180 knots
LANDING SPEED	155 knots
MAX. LANDING VSI	12 ft/s
TAKEOFF/LANDING RUN	1,400 m
CRUISING SPEED	480 knots *
CRUISING ALTITUDE	46,000 ft *
MISSION RADIUS	600 nm (Unrefueled)
STALLING SPEED	101 knots (Sea Level) *
MAX. AoA	41 °
G LIMIT	+6

* Own Estimates

The F-117A has no high-lift devices and low CLa (increase of lift with AoA) so at all speeds, angle of attack will be positive for level flight. Stalling characteristics are highly unpredictable. Never stall the F-117A. Maneuverability is low and flight is subsonic.

Landing is complicated by a high AoA which means that the pilot can lose sight of the runway. Furthermore, as landing speed is high, always deploy brake chute on landing, but never before touchdown.

DEVELOPMENT HISTORY

Another development since World War II is that radar has created an open battle field for aircraft. Any attack in enemy territory involved the risk of being detected early - in fact, in the late 60s, the risk was a certainty, without an extensive array of radar jamming equipment, radar warning devices and chaff-bombs. Often, these were carried by other aircraft, with strike aircraft headed for the primary target, and the majority of the aircraft in a mission acting as defense-suppression aircraft.

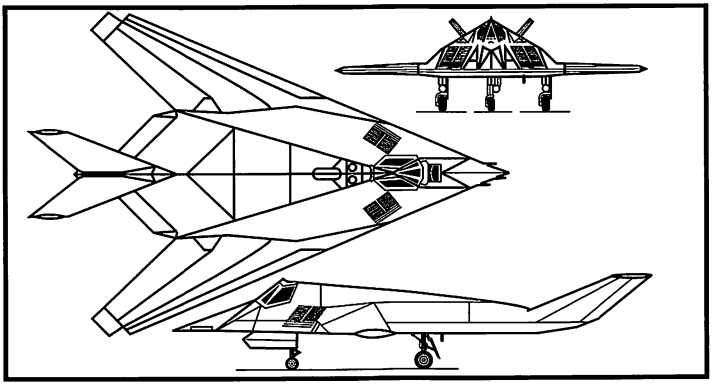
Jamming techniques struggled, and often failed, to keep up with new radar technology. Radar absorbent materials (RAM) were being developed, but did not in themselves provide the necessary reduction in radar cross-section (RCS) to be of real benefit. Some engineers envisaged a more comprehensive solution. In 1975, the US Air Force held a Radar Camouflage Symposium, the proceedings of which have not yet been declassified. The same year, Engineers at Lockheed's 'Skunk Works' designed an aircraft with hardly any curved surfaces at all. The simple concept was that a sharp edge reflects much less radiation than a rounded surface. The trick was in predicting every possible path of reflected radiation from its source to the aircraft to its final direction, and this was only possible with the new computer technology becoming available in the late 70s.

After some tests on the basic shape, Lockheed obtained funding from the Defense Advanced Research Project Agency (DARPA) for two sub-scale flying prototypes of a stealth attack aircraft. Code named, Have Blue, the project went ahead, after control was transferred for security reasons from the civilian DARPA to the USAF. Little was heard publicly of stealth until the mid 80s.

The first Have Blue prototype flew in early 1978, testing flying characteristics. The second was given the complete stealth treatment, with RAMs and tightly-fitted panels, for tests against captured Soviet radar-guided missiles and other threats. The first prototype was lost in a crash due to a high vertical speed on final approach, but the second went on to prove the capability of a nearly radar invisible design, before itself crashing.

The full-scale development program was code-named Senior Trend, and a full-size F-117A was flown on June 18th 1982. The aircraft is not known to have an official name, but is variously known as Stealth Fighter, Nighthawk, and Black Jet. The Groom Lake development testing team named it the Scorpion.

CONFIGURATION

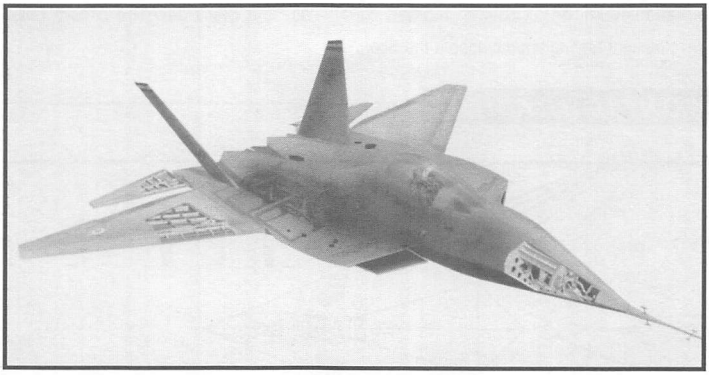


The F-117A was designed to resolve two conflicting requirements - stealth and the ability to fly - but does so very well. Inevitably unstable in all three axes, it is made 'flyable' by a GEC Astronics flight control system, as used by the F-16.

The faceted shape is not ideal for smooth airflow, but there are advantages. Use is made of 'vortex lift', whereby low pressure vortices are formed over the wing and body at high angles of attack, augmenting lift. The high sweepback is necessary, because due to aerodynamic and structural demands, the leading edges of the wings must have appreciable curvature. This means that they will reflect radar, but the sweepback ensures that they reflect a frontal radar signal sharply away from the source.

The sharply swept wing behaves in some ways like a delta, especially at low speeds, when, due to the low aspect ratio and lack of any high-lift devices, high angles of attack are necessary. This is one reason for the unusually high take-off and landing speeds.

LOCKHEED F-22 SUPERSTAR



SUPPLIER	Lockheed Advanced Development Company (LADC)
TYPE	Large, stealth-capable air superiority fighter
	Secondary ground attack role
ENGINES	2 Pratt & Whitney F119-PW-100 Turbofans
SEA LEVEL RATED THRUST	155 kN (Afterburning)
	111 kN (Military Power)
THRUST VECTORING	+/- 20° (Vertically)

DIMENSIONS

LENGTH	62.44 ft.
HEIGHT	16.5 ft.
WING AREA	842.4 sq. ft.
WING SPAN	44.75 ft.
TAILPLANE AREA	136.4 sq. ft.
FIN AREA	178.63 sq. ft.

WEIGHTS

OPERATING EMPTY	29,937.6 lbs.
MAX. TAKEOFF	59,875.2 lbs.
INTERNAL FUEL	21,953.8 lbs.
INTERNAL STORES	7,981.6 lbs.

ENVELOPE

MAX. LEVEL SPEED	Mach 2.30 (At Altitude)
SUPERCRUISE	Mach 1.58 (At Altitude)
TAKEOFF SPEED	135 knots *
LANDING SPEED	125 knots *
MAX. LANDING VSI	10 ft/s
TAKEOFF/LANDING RUN	3521 ft.
CRUISING SPEED	675 knots *
CRUISING ALTITUDE	59,000 ft *
COMBAT RADIUS	800 nm (nautical miles)
STALLING SPEED	95 knots (Sea Level)
MAX. AoA	22.50°
G LIMIT	+9

* Own Estimates

NB: All above data refers to production land-based F-22A.

TFX PILOTS' NOTES

Landing gear is likely to be 'hard-wired' (manually controlled) as on the prototype. Handling will be 'carefree'. Effects of internal stores should be minimal, apart from increase in weight.

DEVELOPMENT HISTORY

In the 1950s, supersonic fighters first appeared in large numbers. They had engines which stretched from nose to tail, to produce enough thrust to exceed the sound barrier, with stubby swept or delta wings to minimize drag. It was found that although crossing Mach 1 took tremendous energy, little more was required to push the fighter to Mach 2 and beyond.

In the US, speed was increasingly seen as the fighter's best asset, to the cost of maneuverability and visibility. Lockheed's Starfighter was an example, its high tail proving inadequate at high angles of attack. In Vietnam, only McDonnell's F-4 Phantom II was consistently successful. It was learned (or re-learned) that even in the missile age, combat often came down to out-turning the enemy and bringing cannon to bear. The US Air Force outlined its new requirements in the FX program. The new fighter was to have no greater a maximum speed than the Phantom, but greater range, and vitally, it was to be agile. The winner, McDonnell Douglas' F-15, was the first modern fighter, with a massive wing and the engine power to overcome the drag entailed, not by higher Mach numbers, but the lift-dependent drag of fast turning.

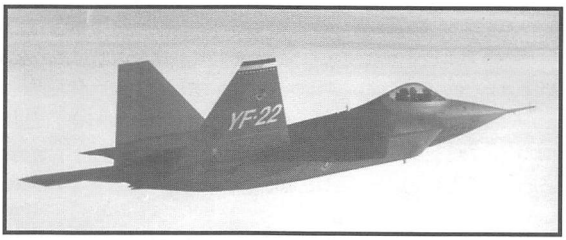
In the early 1980s, when the Reagan administration required work to begin on what was called an Advanced Tactical Fighter, the industry and the USAF outlined the requirements in the light of current technological developments. The ATF was to be a counter-air fighter with supersonic cruise (supercruise), Short Take-Off and Landing (STOL) capability, and a high combat radius. The F-117A was still a close secret, but the prospect of low observability for a fighter was proposed by Northrop among others. The ATF was to have 'low observables' if possible.

Alongside the Air Force program, the US Navy agreed in 1986 to consider a naval version of the ATF (NATF) as a replacement for the mainly air-to-air Grumman F-14.

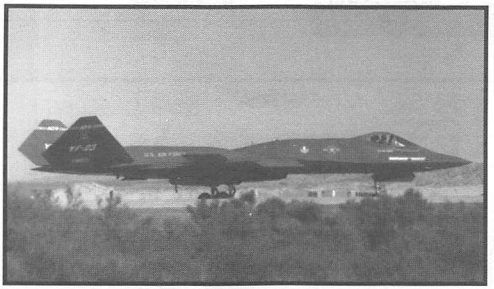
Years previously, Northrop had a competing design to Lockheed's F-117A, similarly faceted, but with a single intake and delta wing. When the F-117A was being tested at Groom, another Northrop stealth airplane, this time without major visible faceting, was also under test. Possibly, new supercomputer systems made it possible to predict the radar response behavior of much more complex shapes, such as Northrop's later B-2 Stealth Bomber. Lockheed too believed in the concept of a true stealth fighter. Of the seven proposals submitted, Lockheed's and Northrop's were considered by the USAF to be the best.

Lockheed, General Dynamics and Boeing agreed to work together if any of them won the contract. Northrop and McDonnell Douglas also agreed to co-operate. The two leading designs were designated YF-22 and YF-23, the Y prefix denoting a combination of new and established technology. Two prototypes of each were to be built and evaluated, in conjunction with flight testing of the two competing ATF engines, the Pratt and Whitney YF-119 and the General Electric YF-120.

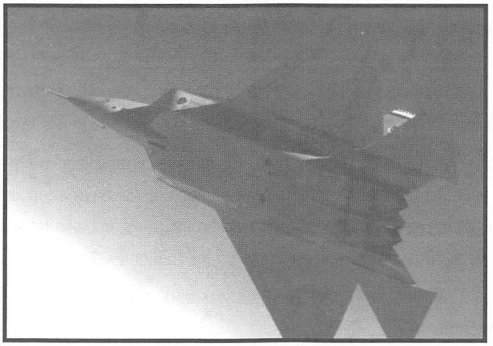
Engine technology was crucial to ATF. For the new challenge of supersonic cruise without afterburner, the low-bypass turbofans were to be in the unprecedented 156 kN thrust range, with a very high proportion available on military power. In the original ATF specification, vertical thrust vectoring was required for manoeuvrability and STOL capability. The result was that the engines had two-dimensional (rectangular) exhaust nozzles, which vectored 20 degrees in either direction. The thrust reversal requirement was deleted, and STOL and thrust vectoring soon followed. However Lockheed decided to include vectoring in their prototype, the YF-22.



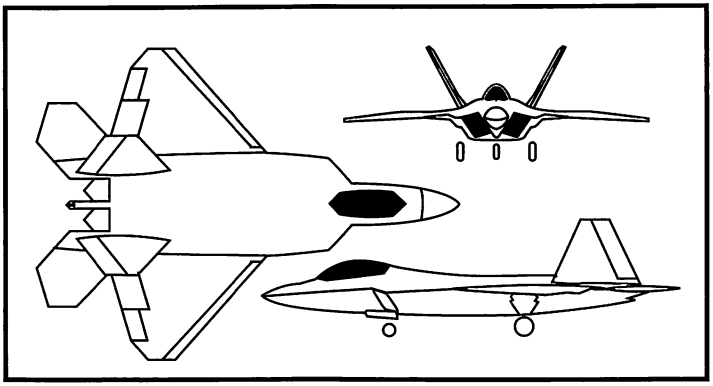
The Demonstration-Validation (Dem-Val) program required each team to state predicted performance of their aircraft, and validate the data in flight. The YF-23 flew first, the design revealed for the first time. A long, sleek structure, reminiscent of Lockheed's SR-71, the YF-23 made use of Northrop's 'seamless' stealth design philosophy.



By contrast, the YF-22 was shorter and more conventional, looking much like a stealthy F-15, which may have been what the Air Force was looking for. Tested to a 60 degrees angle of attack, and, contrary to some reports, to beyond Mach 2, the YF-22 was sold as a super-maneuverable dogfighter. It is thought unlikely that the YF-23 was as agile in pitch as its rival, although according to YF-22 test pilot Tom Morgenfeld, it may have been a little faster in supercruise.



The USAF never made clear their criteria for selection, but the YF-22 was chosen for development as the production ATF, now to be called the F-22. Pratt and Whitney's YF-119 won the engine contract. The Naval ATF, if it goes ahead, may not be based on the same prototype as the Air Force version. Lockheed's own design has major differences, including a larger wing, presumably for lower landing speeds. The landing gear and overall structure will have to be stronger, and stealth will be less of a priority for strike escort and carrier protection.



The F-22 will be the US Air Force's largest fighter yet, with a 842.4 sq. ft. wing area. All weapons are carried internally for stealth. Also due to the requirements of stealth, there are no vertical surfaces, which show up well on radar, so the fins are canted outward at 28 degrees. For stability, the fins will be very large, but not as large as those on the prototype. The sharp breaks or 'chines' on the sides of the nose are also due to this requirement.

The final version will have a modified tailplane, a lower profile, and wings cut off at the outer trailing edge, to reduce the formation of vortices. It will have a leading edge sweep of 42 degrees, as opposed to 48 degrees in the prototype. It will also have a lower profile and a blunter nose. There will be no air brake on production F-22s.

The unique canopy, with no spars, will be retained, giving the F-22 unprecedented visibility for a fighter.

The large trailing edge flaps are to be modified in shape, with the inboard and outboard flaperons having constant chord (forward length). Together with the leading edge flaps, these will form a Mission Adaptive Wing (MAW) as seen on the F-16 and Eurofighter 2000.

appendix four

TFX weapon specifications

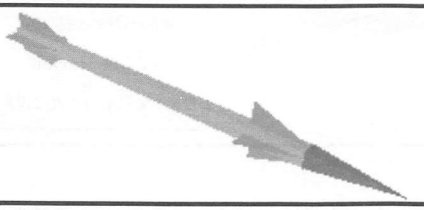
M61B CANNON A modified version of General Electric's M61A1 is fitted to the F-22 Superstar and the Eurofighter 2000 (which is usually fitted with the heavier but otherwise identical 27 mm Mauser Cannon). Note that the F-117A has no cannon. The M61B has 1760 rounds and can fire high velocity 20 mm shells at 6,000 rounds per minute. It is suitable for both air-to-air (dogfighting) and air-to-ground (strafing) situations (the mode is automatically selected). In dogfight mode (DGFT) the moving aiming reticle predicts the enemy plane position by using the aircrafts radar to determine speed and distance so to obtain the best probability for a kill.

The dogfight reticle is split into 4 quarters each quarter shows the range of the fighter you are tracking in units of 1000 ft. from your aircraft. Each quarter will broaden dependent on the distance between you and the fighter. The more broad the circle becomes the closer the target.

In STRF mode the aiming reticle is fixed in the center of the hud and the area inside the ring shows the impact point of the cannon.

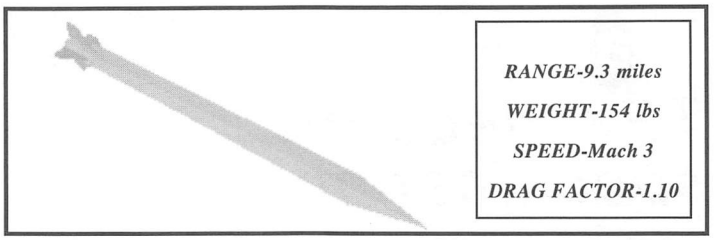
RANGE-1.24 miles
WEIGHT-191.4 lbs.
SPEED-N/A
DRAG FACTOR-N/A

AIR-TO-AIR WEAPONS

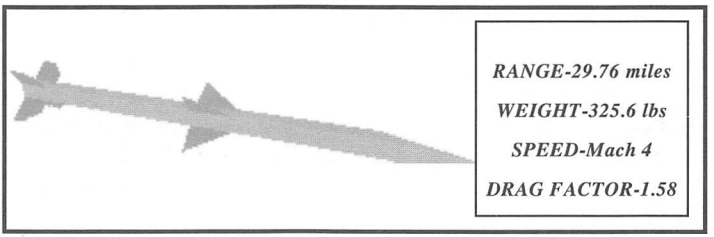


RANGE-9.92 miles
WEIGHT-191.4 lbs.
SPEED-Mach 2
DRAG FACTOR-1.01

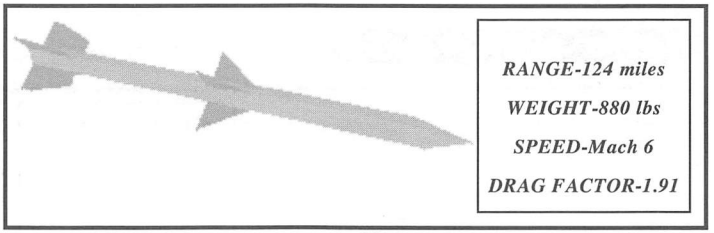
AIML AND AIM 9S SIDEWINDER is an infared guided missile with a short range that locks onto the hot gas trail left by the target aircraft. The AIM 9L is the latest generation of the Sidewinder family and the seeker is capable of hitting the target at all aspects. The AIM9S is smaller and faster and more manouverable than the SL but with a smaller seeker suitable for rear aspect hits.



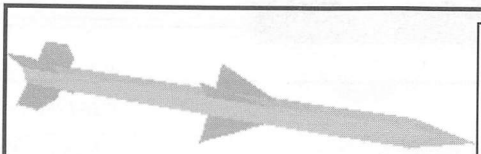
ASRAAM The infrared-guided Advanced Short Range Air-to-Air Missile can obtain a lock on the target aircraft from any angle. It is intended for use in close air combat.



AMRAAM The radar-guided Advanced Medium Range Air-to-Air missile can lock on to an aircraft up to 29.76 miles away. The missile's so-called Beyond Visual Range targeting makes it a formidable weapon.



AAAM A long range missile which can lock on to an aircraft up to 70 miles away. It has mid-course guidance and active radar.



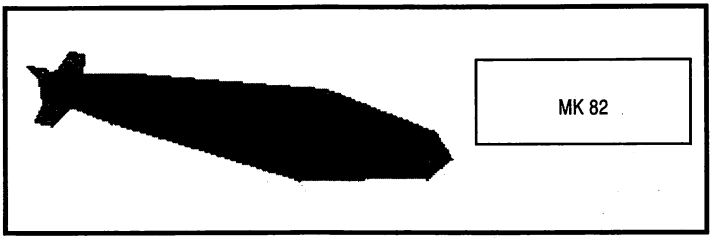
RANGE-124 miles

WEIGHT-572 lbs

SPEED-Mach 5

DRAG FACTOR-1.91

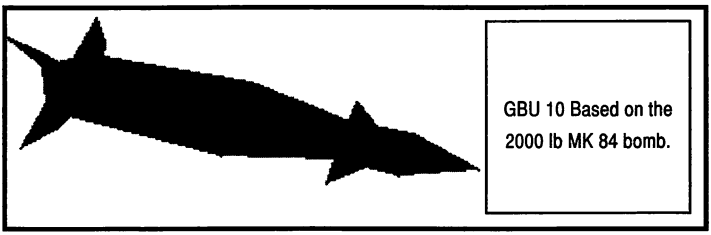
AA-ARM Very little information is available but the Air-to-Air Anti-Radiation Missile is believed to have active radar and a range of up to 124 miles, making it a lethal 'fire and forget' weapon.

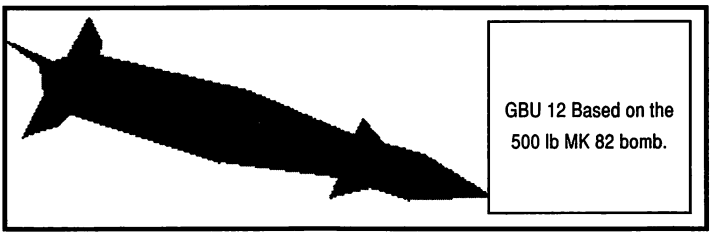


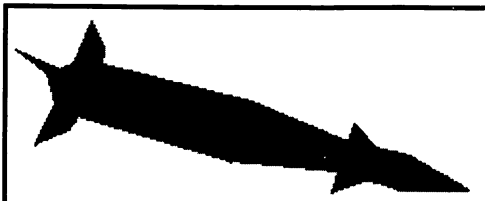
MK 82 An unguided 'iron bomb' with a 500 lb high-explosive charge. The weapon is aimed at the target by means of trajectory-predicting crosshairs on the aircraft's HUD.

RANGE-Determined by Release Height and Aircraft Speed
WEIGHT-495 lbs
SPEED-Determined by Release Height and Aircraft Speed
DRAG FACTOR-1.35

THE GBU 'PAVEWAY' SERIES The following laser-guided bombs all use the same type of guidance unit. A laser from the aircraft illuminates the target with a light of known frequency. The guidance unit then locks on to the reflected laser light and guides the bomb to its target. With this method of guidance the bomb can be placed within inches of the laser spot.



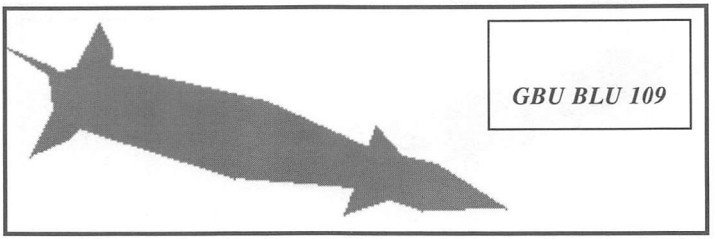




GBU 16 Based on the 1000 lb MK 83 bomb.

GBU 24 Based on a 2000 lb bomb.

RANGE-Determined by Release Height and Aircraft Speed	***GBU 10-1.35***
WEIGHT-See Above	***GBU 12-1.90***
SPEED-Determined by Release Height and Aircraft Speed	***GBU 16-2.55***
DRAG FACTOR-2.55	***GBU 24***



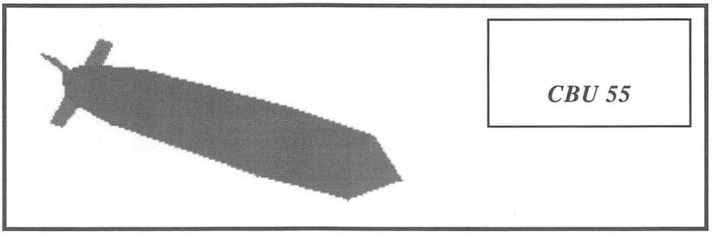
GBU BLU 109 A hardier version of the GBU 24. The bomb is laser-guided and has a 2000 lb high-explosive charge with a head especially designed to penetrate and destroy hardened targets.

RANGE-Determined by Release Height and Aircraft Speed

WEIGHT-2068 lbs

SPEED-Determined by Release Height and Aircraft Speed

DRAG FACTOR-2.50



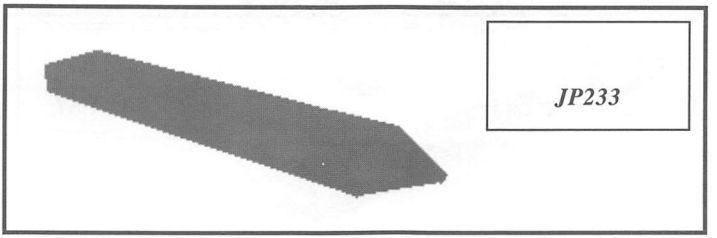
CBU 55 A laser-guided bomb which destroys its target by creating a large cloud of fuel vapor with one explosion then igniting this cloud with a second explosion. The resultant massive shock wave can cause large scale structural damage.

RANGE-Determined by Release Height and Aircraft Speed

WEIGHT-550 lbs

SPEED-Determined by Release Height and Aircraft Speed

DRAG FACTOR-1.80



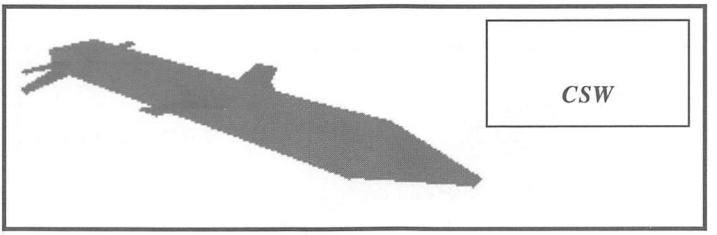
CMB 18 Dispenses pavement-cratering 'bomblettes' capable of destroying runways. Also included are anti-personnel mines which explode on contact or at random to hamper repairs to the runway.

RANGE-Determined by Release Height and Aircraft Speed

WEIGHT-1980 lbs

SPEED-Determined by Release Height and Aircraft Speed

DRAG FACTOR-1.57



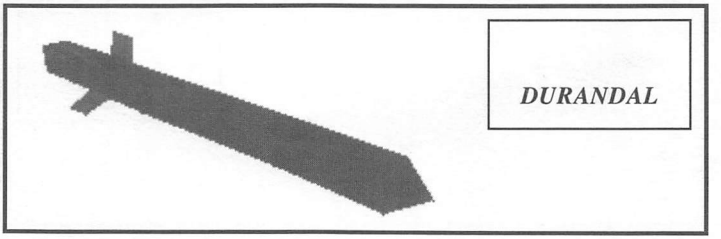
CSW The Conventional Stand-off Weapon is basically a CMB 18 with a launcher. It can be launched at long range from which it cruises to its target before releasing its payload. The target or target area is made using the lazer target designator and the weapon will fly its way to the target and release its payload across an area. The individual bomblettes, 250 of them per CSW, home in on armor and other vehicles causing large scale damage.

RANGE-12.4 miles

WEIGHT-2200 lbs

SPEED-N/A

DRAG FACTOR-2.00



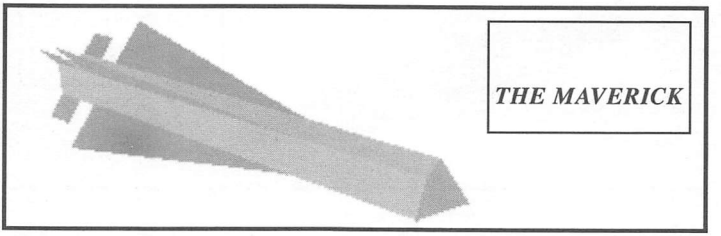
DURANDAL Another runway cratering weapon. Once it is dropped over a runway, a parachute slows the missile's descent and presents it at the correct angle of approach before its motor ignites. The missile penetrates the concrete by up to 400 mm before exploding deep into the ground and causing severe damage.

RANGE-Short

WEIGHT-429 lbs

SPEED (MAXIMUM)-685 mph

DRAG FACTOR-1.57



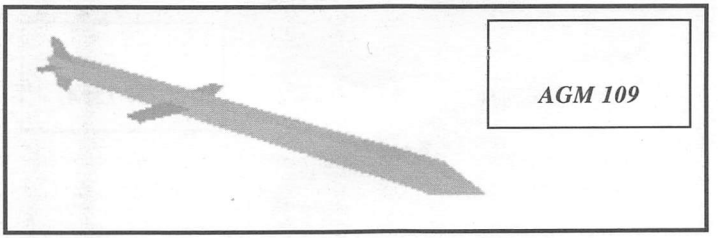
AGM 65D is an infared laser guided fire and forget weapon which is locked on using the infared laser designator. Once launched, the weapon is a fire and forget which homes in on its target even if it is a mobile such as a tank or small ship.

RANGE-24.8 miles

WEIGHT-462 lbs.

SPEED-Mach 1.50

DRAG FACTOR-2.10



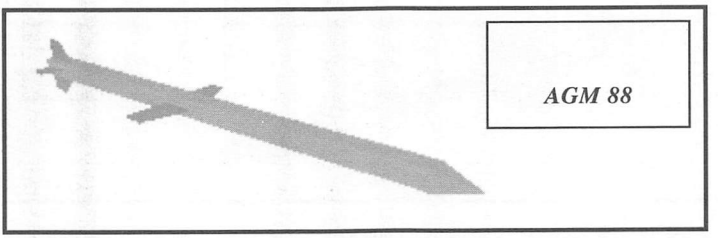
AGM 109 An airfield attack cruise missile which can be launched as far away as 186 miles. It uses digital scene-matching area-correlation guidance and deploys multiple 'bomblettes' across its target zone. When using the AGM 109, its target is pre-programmed prior to the start of the mission.

RANGE-509 km

WEIGHT-1,315 kg

SPEED-Mach 0.60

DRAG FACTOR-7.03



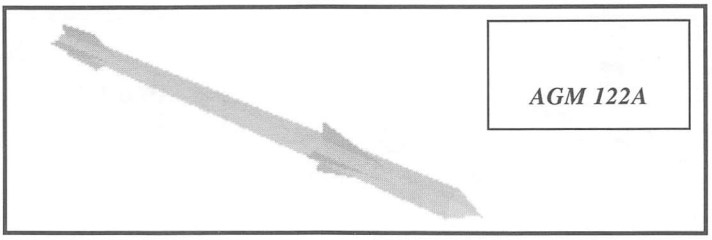
AGM 88 The High-speed Anti Radiation Missile (HARM) homes in on enemy radar signals. It can also be fired 'blind' whereupon it will seek out any transmitters.

RANGE-11.16 miles

WEIGHT-794.2 lbs

SPEED-Mach 2

DRAG FACTOR-2.53



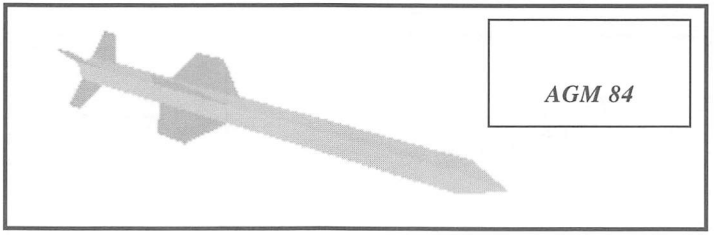
AGM 122A A smaller version of the HARM missile. Its range and power are reduced but it does have a higher speed.

RANGE-4.96 miles

WEIGHT-200.2 lbs

SPEED-Mach 3

DRAG FACTOR-2



AGM 84 The 'Harpoon' is primarily an anti-ship missile which is aimed by the pilot. It is capable of devastating ships as large as Destroyers.

RANGE-57.04 miles

WEIGHT-1157.2 lbs

SPEED-Mach 0.75

DRAG FACTOR-3.19

appendix five

other TFX aircraft, targets and weapons

ALLIED AIRCRAFT

BOEING E-3 SENTRY

TYPE	-Mobile radar command control and communications centre Airborne Warning And Control System (AWACS)
ORIGIN	-USA
DIMENSIONS	
LENGTH	153.8 ft.
HEIGHT	42 ft.
WINGSPAN	146.6 ft.
WEIGHTS	
OPERATING EMPTY	324,317 lbs
MAX. TAKEOFF	331,804 lbs
MAX. SPEED	460 knots

BOEING CH 47D CHINOOK

TYPE	Transport helicopter
ORIGIN	USA
DIMENSIONS	
LENGTH	99.46 ft. (Rotors Turning)
WIDTH	12.47 ft.
HEIGHT	19.04 ft.
ROTOR DIAMETER	60.36 ft.
WEIGHTS	
EMPTY	26,862 lbs
MAX. TAKEOFF	53,887 lbs
SPEED	154 knots

LOCKHEED C130 HERCULES

TYPE	Tactical transport aircraft
ORIGIN	USA
DIMENSIONS	
LENGTH	98.31 ft.
HEIGHT	38.48 ft.
WINGSPAN	133.35 ft.
WEIGHTS	
EMPTY	76,309 lbs
MAX. TAKEOFF	70,310
SPEED	325 knots

AIR-BASED THREATS

F-16 'FIGHTING FALCON'

ORIGIN	USA
DIMENSIONS	
LENGTH	49.80 ft.
HEIGHT	16.76 ft.
WINGSPAN	31.19 ft.
WEIGHTS	
OPERATING EMPTY	15,554 lbs
MAX. TAKEOFF (AIR-TO-AIR)	23,760 lbs
MAX. TAKEOFF WEIGHT	35,325 lbs
MAX. SPEED	Mach 2+

MiG-21 'FISHBED'

ORIGIN	USSR
DIMENSIONS	
LENGTH	48.18 ft.
HEIGHT	14.85 ft.
WINGSPAN	23.60 ft.
WEIGHTS	
OPERATING EMPTY	11,440 lbs
MAX. TAKEOFF	18,700 lbs
MAX. SPEED	Mach 2.1

MiG-29 'FULCRUM'

ORIGIN	USSR
DIMENSIONS	
LENGTH	56.76 ft.
HEIGHT	14.52 ft.
WINGSPAN	37.95 ft.
WEIGHTS	
OPERATING EMPTY	17,985 lbs
MAX. TAKEOFF	39,608 lbs
MAX. SPEED	Mach 2.3

SA-6 GAINFUL Mobile, air-portable and amphibious, low to medium-altitude Surface-to-Air Missile (SAM) system. It's a rather old-fashioned SAM but has been shipped in great quantities and is still a threat. The SA-6 was highly effective in the 1973 Middle East conflict, forcing Israeli aircraft to fly low ... and into the range of ZSU23-4 self-propelled anti-aircraft guns and SA-7 Grail SAMs.

EFFECTIVE RANGE	2.3 - 15 miles
EFFECTIVE ALTITUDE LIMITS	262.5 - 47,244 ft
SPEED	Mach 2.5
WARHEAD	176 lbs

SA-7 GRAIL The most widely used shoulder-launched SAM in the world. It has been shipped to many Guerrilla units who have made use of it to shoot down enemy aircraft. Because the SA-7 can be launched from anywhere, it poses a serious threat to aircraft at lower altitudes. A direct hit can bring your aircraft down.

EFFECTIVE RANGE	150-10,000 ft.
EFFECTIVE ALTITUDE LIMITS	150-14,000 ft.
SPEED	Mach 1.95
WARHEAD	5.5 lbs

STINGER A portable infrared shoulder-launched SAM designed to bring down any low-flying aircraft. The Stinger is in service in many countries and has even found its way into terrorist factions world-wide. Extensive training is require to make this weapon effective. The warhead is a high explosive fragmentation device with a proximity fuse.

EFFECTIVE RANGE	660 - 16,500 ft.
EFFECTIVE ALTITUDE LIMITS	33 - 15,750 ft.
SPEED	?
WARHEAD	6.6 lbs

T-72 MAIN BATTLE TANK The T-72 entered production in 1971 and since then has been used extensively in its home country and abroad. It has a 125 mm smoothbore barrel fed by an automatic loader which holds 24 rounds of ammunition. The T-72 is capable of laying its own smoke trails and is fitted with an NBC system and night vision equipment.

ORIGIN	USSR
CREW	3
ARMAMENT	125 mm Gun
	7.62 mm Machine Gun
	12.7 mm Antiaircraft
ARMOUR	Classified
DIMENSIONS	
LENGTH	30.49 ft.
HEIGHT	7.82 ft.
WIDTH	11.88 ft.
WEIGHT	90,200 lbs
SPEED	37.2 mph
RANGE	300 miles

ZSU-24-4 SHILKA ANTI-AIRCRAFT ARTILLERY This self-propelled anti-aircraft system has an onboard radar which carries out search, detection, tracking and other firing controls. Targets can be acquired on the move but the Shilka normally comes to a halt before opening fire.

ORIGIN	USSR
CREW	4
ARMAMENT	4 x 23 mm cannon
ARMOUR	9.2 to 15 mm
DIMENSIONS	
LENGTH	21.45 ft.
HEIGHT	7.43 ft.
WIDTH	9.75 ft.
WEIGHT	45,100 lbs
SPEED	27 mph
RANGE	280 miles

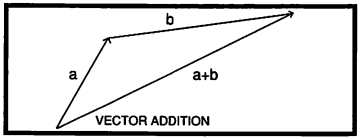
appendix six

the simulation

INTRODUCTION

A simulation is a program which approximates a real situation. In a flight simulation, this is done by setting up the rules of physics and aerodynamics and treating an airplane as a set of key data, such as wing area, mass and so on.

TFX includes a flight model which does this. The main forces acting on the aircraft are calculated, and added together as vectors, producing a resultant force vector. Like normal numbers (called scalars) vectors can be added to each other. They cannot be multiplied by each other in the normal sense, but you can multiply a vector by a scalar, which multiplies its magnitude, keeping its direction the same. Vectors are a way of using maths to apply to the real world, which has three dimensions.



The world works according to certain laws, which were written down first by Sir Isaac Newton (1642-1727). Newton's First Law states that any object will continue travelling with the same speed and in the same direction unless something else changes it. Both speed and direction can be defined by a single vector: a velocity vector.

In TFX, your plane has a velocity vector, which only changes from frame to frame due to the action of the acceleration vector, which changes the velocity vector in the following way:

$$v = v + a \times \Delta t$$

Δt ('delta t') is a scalar, the length of time in one frame. Obviously, real life does not work in frames, but the smaller the frame time, the more accurate the calculation will be. The length of the time interval is determined by the speed of your machine. If the acceleration vector is in the same direction as the velocity vector, it will change the size of the velocity. If part or all of the acceleration vector is perpendicular (at right angles) to the velocity, the direction of the velocity vector will also be affected.

To find the acceleration, Newton's Second Law is used:

ACCELERATION = FORCE/MASS

In vector terms:

$$a = F / m$$

F is the force vector, found by adding all the force vectors affecting the airplane end to end. There is a force vector for gravitational force (weight), one for aerodynamic force, one for thrust, and so on. A similar, but more complex set of rules are used in determining the angular (rotational) behavior of the aircraft.

FORCES

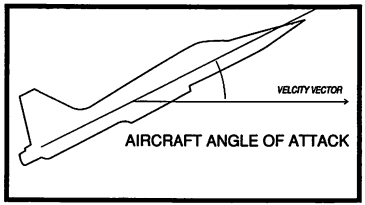
The aerodynamic forces are determined by the aircraft speed V, air density ρ (rho), wing area S, and appropriate coefficients such as, CL or CD.

Lift is the force which keeps an airplane in the air, by acting against gravity. Drag is the force opposite to the direction of travel, which Thrust, the engine force, must overcome. Because drag is inevitable and lift is desirable, these are the main aerodynamic forces.

There is another aerodynamic force, sideforce, but this is usually small, as the aircraft is symmetrical, and sideslip angle β (beta) is mostly small (a few degrees), whereas angle of attack α (alpha) can be as high as 60 degrees in some maneuver.

LIFT $L = 1/2\rho V^2 S\ CL$

DRAG $D = 1/2\rho V^2 S\ CD$

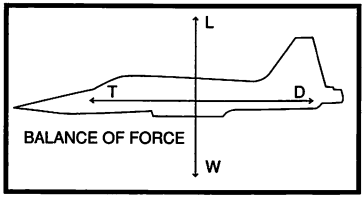


This is a way of looking at aerodynamic forces which shows the principal factors involved. For example, if everything else is the same, then doubling air density ρ will double lift and drag.

For steady level flight:

L = W

D = T



CL depends on wing shape, angle of attack, α, wing cross-section shape, and other factors (see below).

MOMENTS

Moment is the angular equivalent of force. The pitching moment CM determines rotation up or down relative to the aircraft. It is important, because it helps to determine angle of attack.

$$\text{PITCHING MOMENT } \mathbf{M} = 1/2\rho V^2 \, \mathbf{S} \, \mathbf{CM}$$

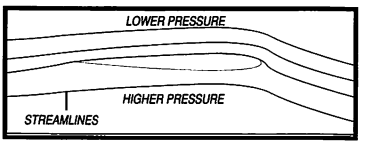
CM is determined by α, by rate of pitch, q, and by elevator deflection, η (eta). For stability, a positive angle of attack should produce a negative CM to counteract it, so if the pilot does not move the elevators using the joystick, the aircraft will pitch down again.

COEFFICIENTS

Although the equations above show variations of lift, drag and moment with the main factors, the coefficients vary in several ways. In addition to the variation of lift with the square of speed, lift coefficient CL also varies with speed and other factors. You might then ask what the difference is between the V^2 factor in the lift equation and the way velocity affects CL. The answer is simply that the coefficient is a useful way of comparing different wings and airplanes. The term ($1/2\rho V^2$) is called dynamic pressure, and describes the pressure decrease when air travels at a certain speed. Of course, the air at different parts of an aircraft travels at different speeds, but V is the overall airspeed, and describes the general speed for purposes of discussion.

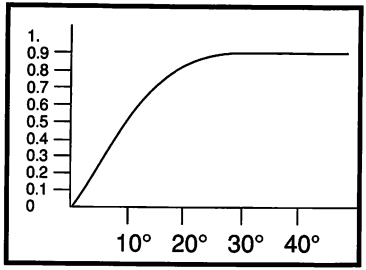
LIFT

As seen below, airflow over a wing generates lift because after the flow splits in two at the front of the wing, the shape of the wing causes the air over the top to travel faster in order to meet up with the air under the wing, as the curvature gives it a greater distance to travel. Even if the wing is symmetrical, angling it to the airflow means that the air does not split at the front of the wing, but on the underside, producing the same effect as an asymmetric ('cambered') wing.



AIRFLOW OVER A WING SECTION

In general, the major variation of CL occurs when angle of attack a is changed. As seen below, at a certain angle for a given plane, CL is zero. As a increases, so does CL, up to a point when CL is highest. After this, the wing is at too high an angle for the air to flow smoothly from the leading edge to the trailing edge of the wing. It begins to 'separate' or stall, producing a wake of low-pressure air behind the wing. As pressure behind the wing is low, this pulls back on the wing, acting as drag, without producing any extra lift.



CL v. alpha

Separation can occur unevenly on the wing, leading to unwanted rolling or yawing moments. So, increasing angle of attack beyond the stall angle is not only pointless, but dangerous.

Now return to the lift equation:

$$\text{LIFT } L = 1/2 r V^2 S C_L$$

Hold ρ and S constant for a minute, and assume that, for level flight, L must equal weight W. We are left with V and CL. Bunching the rest together:

$$V^2 C_L = \text{CONSTANT}$$

or:

$$C_L = \text{CONSTANT}/V^2$$

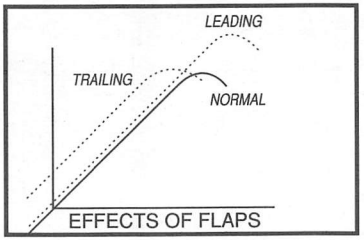
So, if we change one of these two variables, the other must also have a new value in order for the equation still to work. Decreasing V, we must increase CL. However, we have already learned that CL can only go so high before the wing stalls. So, V can only go so low, before you are flying along at the stall angle, and when you try to decrease speed further and increase a to get more lift, you will find that you don't get any more lift, and you will stall. This speed is called the stalling speed and is the slowest speed at which the plane can fly level.

The maximum lift depends very much on the shape of the wing. Many airplanes use special methods to change the shape of the wings during flight. Two examples are shown below:

A TORNADO'S SWING WINGS

The Tornado (left) has a variable sweep (swing wing) design. At low speeds, the wings have a low sweep angle (they are almost at right angles to the airflow). This gives high lift, but produces more drag than the opposite setting, used at high speeds, whereby the wings are swept back sharply, producing lower lift and drag coefficients (as speed is high enough to use lower lift coefficients). The YF-22 uses flaps to increase lift. These hinged devices at the leading and trailing edges increase the effective camber (curvature) of the wings, producing greater maximum lift coefficients, again at the expense of drag.

Both of these are examples of the Mission Adaptive Wing (MAW), the concept of in-flight adjustments to wing shape making airplanes more versatile. In TFX, both the F-22 and the Eurofighter have a leading and trailing edge flap MAW configuration. Both types of flap increase the stalling angle and maximum CL, but trailing edge flaps also increase the lift at all angles of attack (see below).



EFFECT OF LEADING AND TRAILING EDGE FLAPS

The flight control system automatically takes care of flap adjustments, selecting the best settings at all speeds and altitudes. You can see the positions of the MAW by selecting the control display on one of the cockpit MFDs.

The F-117A has no high lift devices of any kind, and is thus forced to take off and land at high speeds, and often fly at very high angles of attack. Luckily, the sharp sweep of the F-117A's wings, and the shape of the plane's body give higher lift than other planes would have without flaps.

DRAG

Drag, on the whole, is undesirable, and most aircraft design with respect to drag is intended to minimize it. Sometimes, however, it is necessary to reduce speed, and then an increase in drag, sometimes using air brakes or spoilers is useful.

There are several kinds of drag. Four important ones are Friction Drag, Pressure Drag, Induced Drag and Wave Drag.

Friction Drag is due to the viscosity of the air passing around the aircraft. The friction drag coefficient remains roughly constant as speed increases.

Pressure Drag is due to a decrease in pressure of the air as it passes the aircraft. Stalling causes a large pressure drop-off in the wake of the wings, and so pressure drag is large.

Induced Drag is caused by lift. In fact, it is that part of the force due to circulation (the effect which causes lift) which acts in the direction of airflow. The higher the lift coefficient, the higher the induced drag. The section on control shows how induced drag in maneuvering limits the sustained maneuverability of a fighter. Using induced drag is another way to lose speed - by flying in a 'zig-zag' path, at high angles of attack, you can 'bleed off' energy.

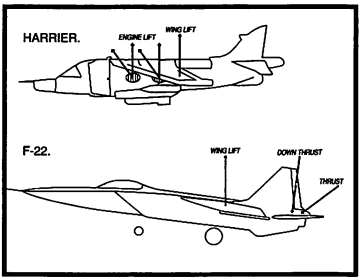
Wave Drag is due to the formation of shock waves at transonic and supersonic velocities. This forms the effective 'sound barrier', whereby the energy required to pass the speed of sound is much greater than that required to make a similar gain in subsonic speed. In a fighter, wave drag can account for perhaps 3/5 of the total zero-lift (non-induced) drag. Swept wings, and specially designed wing sections mean that today's fighters have less wave drag than their predecessors.

Other sources of drag are external stores and landing gear. All of these forms of drag are simulated in TFX.

SOME NOTES ON TAKEOFF

In takeoff, the aim is to attain sufficient lift to leave the ground. For most airplanes, this is achieved by increasing the angle of attack (by raising the nosewheel from the ground) in order to increase lift. For safety's sake, takeoff speed is always significantly higher than stall speed, but there is another reason for this. When on the ground, the rolling force on the wheels acts not only to slow down the aircraft, but also to pitch the nose down. You can get the same effect, only exaggerated, by turning on the brakes at 60 kts. A major problem in shortening the takeoff distance is obtaining enough aerodynamic pitching moment to turn the nose skyward.

Although many fighters have more thrust available than weight, using engines instead of wings for lift is still very inefficient. The Harrier is capable of vertical takeoff due to its thrust vectoring nozzles, but in doing so uses fuel that could otherwise extend range significantly. For this reason, most Harrier missions start with a short, but not vertical takeoff. The F-22 uses thrust vectoring in a different way. Instead of assisting the wings with engine thrust, the F-22 diverts its vector nozzles upward.



THRUST VECTORING IN TAKEOFF

The down-thrust from the F-22 engines, as well as the downward force from the elevators, has the effect of turning the whole aircraft nose-up, increasing the angle of attack and gaining enough lift from the large wings, with flaps deployed, to more than counteract the downward thrust and lift the aircraft from the runway. This system makes the F-22 with thrust vectoring a short takeoff aircraft.

The Eurofighter 2000 solves the problem in a different way. In contrast to traditional tailplaned designs, the Eurofighter's foreplanes raise the nose from the ground at the same time as providing extra lift. As the rolling force is proportional on the total downward force through the wheels (i.e., weight - lift), this further decreases rolling force and helps the aircraft to get airborne.

TFX simulates ground forces by treating each wheel as a separate system, with suspension, shock-absorption, rolling forces and brake forces.

appendix seven

glossary of terms

AA *or* **A-A** *Air-to-Air*

AAA *Or* **'Triple A'** *Anti Aircraft Artillery*

AFTERBURNER *Part of a jet engine that increases the power of the engine by mixing fuel with the jet exhaust*

AG *or* **A-G** *Air-to-Ground*

AGM *Air-to-Ground Missile*

AILERON *Control surface on an aircraft wing that produces aircraft roll*

AIM Air *Intercept Missile*

All-Aspect *Weapons that are effective at any angle to the target*

ALT Alti *tude above sea level*

AMRAAM *Advanced Medium Range Air-to-Air Missile*

ARM *Anti-Radiation Missile, a missile which targets radio-emitting targets such as radar*

AoA *Angle of Attack*

AUTO PILOT *A mode in which the flight control computer takes over the control of the aircraft, leaving the pilot with less to do*

AVIONICS *Electronic systems in the aircraft*

AWACS *Airborne Warning And Control System*

BANDIT *Enemy air threat*

BANK *To roll the aircraft to one side and induce a turn*

BINGO *Fuel is low*

BLACKOUT *Loss of consciousness due to excessive forces on the pilot*

BLAST-FRAGMENTATION WARHEAD *An explosive charge which creates a large amount of shrapnel*

BOGEY *Enemy air threat*

BREAK *To suddenly turn in the hope that any enemy following will lose his tactical advantage*

BVR *Beyond Visual Range*

CALLSIGN *A pilot's codename*

CAP *Combat Air Patrol*

CHAFF *A package of foil strips which produce large radar targets for radar guided missiles*

CONTINUOUS WAVE RADAR *A system which emits radio waves continuously, as opposed to pulses (see PULSE DOPPLER RADAR)*

COURT MARTIAL *A military trail held when breaches of conduct codes occur*

DLIR *Downward Looking InfraRed*

DOGFIGHT *Engaging enemy fighters*

DRAG FACTOR *A number which indicates how un-aerodynamic external stores on an aircraft are*

DURANDAL *Runway cratering missile*

ECM *Electronic Counter Measures*

EW RADAR *Early Warning Radar*

FIRE AND FORGET *A missile that once fired, will guide itself to its target*

FLAK *Shrapnel produced by AAA shells exploding*

FLAPS *Control surfaces on aircraft wings which increase lift for a given flight condition and allow a lower airspeed than is normal in flight*

FLARES *Pyrotechnic packages which burn with intense heat designed to confuse infrared missiles*

FLASHPOINT *A trouble zone, be it economic, military or otherwise*

FLIR *Forward Looking InfraRed*

FLY BY WIRE *The control system in an aircraft where the pilot inputs his controls via a computer which flies the aircraft*

G *A force experience by the aircraft and pilot when maneuvering the aircraft, expressed in terms of the earth's gravitational force*

G-SUIT *A suit worn by pilots which reduces the effects of high g numbers*

GBU *Guided Bomb Unit*

G-LOC *G-induced Loss Of Consciousness*

HARD TARGET *Target which is armored*

HARM *High-speed Anti-Radiation Missile*

HOTAS *Hands On Throttle And Stick*

HUD ***Head-Up Display***

ILS *Instrument Landing System*

IR *InfraRed*

JAMMING *Confusing the enemy radar by using high-energy bursts of a certain frequency*

KC *Mid-air refueling tanker*

KIA *Killed In Action*

KNOCK IT OFF *Slang for 'end the mission'*

KNOT *One nautical mile per hour*

Kts *Abbreviation for Knots*

LIZARD *A term often used to describe the enemy leader*

LOCK *Acquire a target and fix weapons aiming systems on it*

LOOSE CANNON *A renegade pilot*

MACH *Unit of speed equal to the speed of sound at your altitude*

MFD *Multi-Function Display unit*

MIA *Missing In Action*

NAV *Navigation*

NEGATIVE G's *g-force that forces you out of your seat*

POSITIVE G's *g-force that forces you into your seat*

PULSE DOPPLER RADAR *Radar that emits short bursts of radio waves and detects objects by the returning echo*

RDF *Rapid deployment force*

RADAR *RAdio Detection And Ranging.*

REDOUT *Effect felt by pilot when pulling negative g's for too long. Caused by blood rushing to the head.*

ROOKIE *Inexperienced pilot*

RPM *Revolutions Per Minute*

RUDDER *Control surface on the tail of an aircraft which affects the yaw of aircraft*

SAM *Surface to Air Missile*

SLATS *Extendible leading edge high lift devices*

SOFT TARGET *Target without any armour*

STALL *Loss of control due to low airspeed or excessive manoeuvre at high altitude*

THREAT *Any enemy in your vicinity*

THRUST *Power produced by your engines, usually referred to as a percentage*

VSI *Vertical Speed Indicator*

WP *WayPoint*

WAYPOINT *A position in the world to which you have to fly*

WINGMAN *A flying partner*

appendix eight

NEED HELP?

For game customer service, please call 408-954-0201.

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